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The Interaction of Decision Aid Usage, Training Methodology, and Personality Construct on Decision Making Among Dyadic Air Crews in a Military Environment

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ARL-RP-0052

APRIL 2003

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Army Research Laboratory
Aberdeen Proving Ground, MD 21005-5425

ARL-RP-0052 April 2003

The Interaction of Decision Aid Usage, Training Methodology, and Personality Construct on Decision Making Among Dyadic Air Crews in a Military Environment

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Department of Psychology
Human Factors Engineering Program
In the Graduate School
The University of South Dakota
December 2001

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REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)	2. REPORT DATE	3. DATES COVERED (From - To)
April 2003	Final	

4. TITLE AND SUBTITLE The Interaction of Decision Aid Usage, Training Methodology, and Personality Construct on Decision Making Among Dyadic Air Crews in a Military Environment	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER 62716A
6. AUTHOR(S) Schipani, S.P. (ARL)	5d. PROJECT NUMBER H70 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425	8. PERFORMING ORGANIZATION REPORT NUMBER ARL-RP-0052
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Although the workload placed on military decision makers often hinders the achievement of optimal solutions, concern given to issues such as methods unique to grouped individuals in acquiring, processing, and acting upon information is often inadequate. The current research examined two levels of *training*, *decision aiding*, and *homogeneity* on group performance, using a personality concept classified "action orientation". Tasks concerned pre-flight safety assessments for military combat aircraft and were performed by Army Cobra aviators. Dependent measures included a quality score composed of identified mishaps with contingencies for remediation and time taken to complete tasks. Advanced *training* produced an increase of more than 41% in mean response quality when *decision aids* were allowed and 38% when not, although use of the *aid* caused increases in completion times during these situations of 12 and 14 minutes, respectively. Collectively, the most highly trained participants allowed that the *aid* produced improvements of more than 4.5-fold above less trained counterparts who were not provided an *aid*. Although the effect of group *homogeneity* was moderately correlated with two competing independent variables, when we controlled for the variance accounted for by these, *homogeneity* was shown to be a significant predictor of performance. Of primary significance, since performance was verified as vacillating per level of *training* and with or without provision of a *decision aid*, the contingent theory of decision making put forth, which proposed that actions taken depend on the existing situation, could be supported. Also supported were the propositions that decision maker expertise fluctuates during the process as a consequence of circumstance and that maintenance training and decision aiding conjoined should benefit the process, which suggests that human performance in such situations is malleable. Thus, the intent of system designers should be the development of practical training programs and aiding systems aimed at overcoming human algorithmic reasoning limitations, while enhancing environments for heuristics rationale. In this, all levels of operator should benefit; the expert conferred restraint from insufficient alternate scans, while the novice offered essential supplementary information.

15. SUBJECT TERMS

action control theory   decision aids   decision making   homogeneity   training

16. SECURITY CLASSIFICATION OF			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Salvatore P. Schipani
Unclassified	Unclassified	Unclassified	UL	230	19b. TELEPHONE NUMBER (Include area code) 410-278-5890

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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Acknowledgments

I would like to express most sincere gratitude to Dr. Douglas Peterson for assistance with the original concept but particularly for his generous and untiring advisory support during the entire process, ensuring the completion of all requirements. With this, my heartfelt appreciation goes to Dr. Jan Berkhout without whom I never would have had sufficient confidence to initiate this endeavor, and lacking his constant encouragement, surely would not have continued. I am grateful to have had the opportunity of studying under these gentlemen and am especially contented that in doing so, we became friends.

I wish to thank my long-standing companion (and often times, mentor) Dr. John Schmidt for his guidance, especially in areas other than experimental design. Given this and our past experiences, I take comfort in the realization that our true friendship should continue indefinitely.

I also extend genuine gratitude to Drs. Gil Reyes and Michael Card for unselfish devotion to this project, even to the extent of quietly sacrificing personal responsibilities in order to do so.

Additionally, I would be negligent if I did not show immense appreciation to my family for continued and persistent support: To my mother, Mary, whom I love dearly for constantly making herself available with characteristic support and guidance; my niece, Lisa, who blossomed into a person I have always admired; my nephew, Luke, his gift the example of true inner personal strength; and to my brother-in-law, Bill, for exhibiting a model of the man I someday hope to become. Although I mention this next person last, I certainly do not hold her in least regard; thus, deepest appreciation is offered to my loving sister Sarah. I do so as I believe that at times, only she truly understood my emotions and allowed empathy when needed most.

For this, I am eternally grateful. To all, *thank you.*

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THE INTERACTION OF DECISION AID USAGE, TRAINING METHODOLOGY, AND PERSONALITY CONSTRUCT ON DECISION MAKING AMONG DYADIC AIR CREWS IN A MILITARY ENVIRONMENT

INTRODUCTION

Workload and time constraints placed on decision makers involved with modern military command and control systems hinder efforts toward achieving optimal solutions, quite often distract operators from the avoidance of critical mishaps (Merket, Bergondy, & Salas, 1999). To enhance decision-making performance particularly in groups (where individual differences multiply complexity), attention must be paid to strategy, operator training, or features of the systems (Cronin, 1998). For this, research has examined an array of probable remedies such as providing tactics via strategic training. Also incorporated are decision supports such as expert systems (Ricci, Salas, & Cannon-Bowers, 1996; Talcott, 1992). However, as promising as these initiatives are, they often neglect to address basic issues such as the fact that individuals have

unique methods in acquiring, processing, and acting on information, as well as associating this new information to the situation at hand.

It is often assumed that tactics and strategy training, coupled with tailored decision support systems, should naturally enhance performance. Unfortunately, this assumption disregards the possibility that a team concept may not have been formed, and thus necessary working relationships developed (Talcott & Holt, 1987). In assuming tactics training most important for required for situation resolution, emphasis appears to be placed primarily on task completion, and not the effectiveness of group interaction. It may, in fact, be as beneficial to consider grouping individuals based on how they operate jointly with the information presented as it has been to modify systems or provide redundant training. More importantly, personal cognitive processing characteristics have not been thoroughly examined, especially in conjunction with provided (or anticipated) decision aiding and training methodology (Hogarth, 1987; March, 1994.; Simon, 1986). With this, the benefits or short-comings for each of the above mentioned variables must be weighted per situation, realizing that operators, as humans, may be obligated to fluctuate among available resources during particular stages of the decision making process per requirements of the given situation.

The current research examined one individual classification, considered a personality construct, during involvement in a simulated

group decision-making activity requiring simultaneous cooperation. Conditions in which a decision aid was provided and when not were presented. Subjects, experienced Army aviators, were further grouped as either having overview training only (basic "Awareness") or afforded both overview plus subsequent serial exercise style ("Skill Development" refresher exercise) pre-flight "Operational Risk Management" training. The activity concerned safety pre-flight assessments for military aircraft, prior to missions.

Group performance was evaluated by assessing the effect of an individual construct (characteristic) classified 'Action' versus 'State' orientation, per the "Action Control Scale" (Kuhl, 1985). In this, not only could performance assessments be made for team homogeneity and its effect on performance, the benefit of decision aiding and type of training afforded could also be addressed. Resultant evaluations are vital during future assessments of team performance and especially for modeling purposes, as the literature lacks empirical instances of such commingled investigations though to do so would appear theoretically grounded.

Overview Of Decision-Making Theory (DMT)

Decision-Making Theory (DMT) is a body of knowledge and related analytical techniques designed to help decision-makers choose from among a set of alternatives in light of their possible consequences. DMT

can be applied under conditions of certainty, uncertainty, or risk,. Decision under certainty means that each alternative leads to only one consequence, and a choice among alternatives is equivalent to a choice among consequences. With decisions under certainty, each alternative will have one of several possible consequences, and the probability of occurrence for each is known (Fischhoff, Slovic, & Lichtenstein, 1977). Therefore, each alternative is associated with a probability distribution, and a choice among probability distributions. When the probability distributions are unknown, one speaks of decision under uncertainty (Sniezek, 1992; Jungerman, 1983; Boyd, & Fulk, 1996). DMT recognized that the rankings produced by using a criterion must be consistent with the decision-maker's objectives and preferences.

DMT offers a collection of techniques and procedures to reveal preferences and to introduce these into models of decision-making. It is not concerned with defining objectives, designing alternatives, or assessing the consequences: it usually considers these as given from out side, or previously determined. Given a set of alternatives, a set of consequences, and a correspondence between these sets, decision theory offers apparently simple procedures for choices. In a decision situation under certainty, a decision-maker's preferences are simulated by a single attribute or 'multi-attribute value function', which introduces ordering on a set of consequences and thus ranks alternatives. DMT for certainty

conditions is based on the concept of utility. The decision-maker's preferences for the mutually exclusive consequences of an alternative are described by a utility function, permitting calculation of the 'expected utility' for each alternative. Alternatives with highest expected utility are considered most preferable (Einhorn & Holgarth, 1981).

For the case of uncertainty, DMT offers two main approaches. The first exploits criteria of choice developed in a broader context by game theory, for example the 'min-max rule' where one selects the alternative such that the worst possible consequence of the chosen alternative is better than (or equal to) the best possible consequence of any other alternative. The second approach is to reduce the uncertainty of risk by use of 'subjective probabilities', based on expert assessments or on analysis of previous decisions made in similar circumstances (Kahneman, Slovic, & Tversky, 1982).

In *Expected Utility Theory* (EUT), a normative model of decision making decisions, decisions are defined as intentions to act based on two categories of reason: 1) desires consisting of preferences, values, and utilities, and; 2) beliefs, consisting of probabilities or expectations (Plous, 1993). Thus, to act rationally implies acting with adequate reason. An *expectation* refers to the belief of how likely an option will lead to a particular outcome, and is typically measured in probabilities. A *value* refers to the strength of the desire for an option's outcome, and is a much

more difficult concept to measure. EUT does not describe how decisions are made, instead decisions are viewed as mathematical procedure influenced by certain properties. One of these procedures is that decisions made according to given weights should maximize expected value, given that the decision-maker is presented with adequate information. Unfortunately, many decision scenarios do not provide such adequacy, especially those involving emotional attributes (Thaler, 1992). Proper application of EUT maintains that one should list all features-options in attempting to place subjective values onto a similar scale, and then assign probabilities to likelihood's for these in the future. Once completed, one can multiply expected feature values of each and sum these.

With *Prospect Theory* (Kahneman & Tversky, 1979) losses appear differently than gains, and a risk-averse attitude may surface as one faces possible gain. Conversely, a risk-seeking attitude may develop when facing possible losses. It may be justifiable to become risk-averse in gains and risk-seeking in losses, however utility theory assumes an 'expected' outcome. This asymmetry also implies that bundled losses are easier to bear than spread out losses, and that spread out gains are more acceptable than bundled gains (Kahneman & Tversky, 1979). This has parallels in social perception, as negative traits and behaviors receive disproportional weight during impression formation as in self-perception, negative views of one's self are particularly strongly held). Humans may, however,

reframe a probable loss as a type of insurance and thus become more willing to accept this (Slovic & Lichtenstein, 1971). Further, humans treat extremely low or high probabilities differently. Low probabilities are often over-weighed, and high probabilities are under-weighted. Prospect Theory allows a more realistic image of actual decision making than does EUT by relying on normed scales, though most daily decisions have neither an exact value associated nor a determined expectation.

To humans, physical stimuli are classified as signals (given high attention values), and humans are motivated to detect the presence and characteristics of these against a background of noise (low attention value). For modeling purposes, this situation is depicted by two distributions (one for the noise and one the signal) which partially overlap per the given dimension (Birnbaum, 1983). Accordingly, persons must decide on a cut-off criterion below which is assumed noise and above which is inferred a signal, the dilemma of *Signal Detection Theory* (SDT) (Swets, 1986). Deciding correctly will result in successful 'hits' (classifying noise as a signal), and 'correctly rejecting' (rejecting noise when otherwise this might be claimed a signal). However, due to the overlap in distributions, two types of error are possible; 'false alarms' (to claim there is a signal present among noise when there is not), and 'misses' (stating no signal exists among noise when one does).

In applying SDT, all possible outcomes are related (Swets, 1988). Hits and misses sum to the number of presented signals, while false alarms and correct rejections sum up the number of presented noise-only instances. Optimal detection requires a strategic balance between minimizing false alarms or minimizing hits. Finding this optimal area depends upon prior probabilities (possibly experienced) of signal and noise and relative costs of errors, or conversely the benefits of successes. Influencing this, if benefits are high, a more lenient criterion is adopted. In contrast, if the costs of mistakes made are high, a stricter criterion is employed. In this manner, SDT emphasizes the importance of choice criteria in detection, in that some satisfactory trade-off must be settled upon. If adequate information is provided and time permits, a more formal approach to decision making may be employed, such as *Bayes' Theorem* of conditional probabilities. This allows an algebraically derived decision via transformations of conditional and joint probabilities (Wolf, Gruppen, & Billi, 1985).

In *Task Analysis*, when the defined outcome is the sum of individual efforts, assuming that whatever outcome decided upon should be better than any individual contribution, such efforts are referred to as *Additive Tasks*. However, this condition may result in 'social loafing' of individual group members. When assuming *Conjunctive Tasks*, the outcome rests on one correct solution, assuming that the group will

perform as well as - though not better than - the one best individual (Hackman & Morris, 1975). Individuals may share a solution they might not have found themselves, or find this faster than they would have otherwise. Such action encourages prompting of responses from other members in the group. With *Disjunctive Tasks,* group resources are pooled and combined, thus the outcome emerges from interaction between individual members. Such situations are ideal if a creative task is presented, and often found more favorable than the additive sum of individual efforts (unless group members are unlikely to share unique information). When two stimuli appear to be closely related, these may be integrated through *Assimilation* rather than seen as one in contrast with the other, especially if the reaction to one lingers, causing similar reaction to the other (Lord, Ross, & Lepper, 1979). The options within a set may provide information concerning worth, 'anchoring' a group member or members on some standard referred to as *Standards of Comparison.* Making context-free decisions is difficult, as our beliefs, attitudes, and preferences are composed in given contexts which often elicit *Primacy* and *Recency* effects on of information.

During considerations of choice versus consequence, attempting to anticipate the future is the most notably decision-making feature, and is labeled *Uncertainty.* This contributes to the difficulty of deciding, since one can rarely fully predict all possible future consequences for choices

(Kahneman, *et al.*, 1982). Another source of difficulty in decision making is *Conflict*, the fact that every choice inherently implies a minimum of two options possessing positive and negative consequences (Sniezek & Buckley, 1995). In selecting one option, one accepts the positive consequences of this, hopefully avoiding negative consequences of any option rejected. However, in doing so one must accept any negative consequences of the chosen option, and lose any positive consequences that may have been gained from the option(s) rejected. This dilemma becomes a major source of *Dissonance*. Dissonance increases as decisions with irrevocable consequences are made (Festinger, 1957). If no option is more appealing (in other words, if both options are either equally attractive or unattractive), conflict arises. In such situations, the decision-maker must accept at least some negative consequence while ignoring positive consequences of the option not selected, which is dissonant with the ideal goal of selecting good outcomes and avoiding bad ones. Dissonance can be experienced even after the decision has been affected, and is increased in social situations (i.e., groups) (Festinger, 1957).

Most of our *Beliefs* are formed through perception, by directly perceiving events or indirectly through communication (Zaccaro, Gilbert, Thor, & Mumford, 1991). Thus, people tend to believe what is perceived, and it takes great effort to correct this. Giving up on a theory or belief is made easier if a more rational option is available, however it is quite

difficult to accept new information lacking a theory within which one's belief may be assimilated (Tesluk, Mathieu, Zaccaro, & Marks, 1997).

Beliefs, attitudes, and theories influence how stimuli are perceived. This leads one to distort information, which results in a confirmation bias in which further information must be sought to confirm the favored (often first) hypothesis rather than giving credit to new evidence even though this may appear contrary (Sniezek & Buckley, 1995). Positive feature affect may further influence decisions by causing people to attend more to instances in which something might actually happen, rather than to those where no visible changes are expected. Humans usually adopt a confirmatory bias when the hypothesis is desirable (in other words, people seek evidence to confirm personal hypothesis), but concern arises when alternatives are abundant or attractive. A variation on this theme is the 'feature positive' effect. This describes our tendency to pay more attention to instances of something happening than to counter-instances of the same not occurring. The 'pseudo-certainty' effect refers to human unwillingness to consider the conditional nature of many decisions, and the resultant tendency to overweight supposedly certain outcomes in a chain of probabilistic events (Einhorn & Hogarth, 1986, 1985, 1978).

Framing effects (of gains and losses) influence decision-makers (Tversky & Kahneman, 1981). The 'saving' frame sets loss at a reference point thus any outcome more favorable than the worst is seen a gain

(leading to risk-averse decisions) (Bettman & Sujan, 1987). The 'losing' frame establishes the current state as the reference point, and any deviation is viewed as a loss leading to risk-seeking decisions.

The influences of over-dependence on context may be manipulated by ones attitudes, impressions, current mood, or sensory system (Sanbonmatsu & Fazio, 1990). Most likely, any decision-eliciting hypotheses appropriate for consideration under an internal mode will be affected by beliefs about ones' self, or the probability of personal future actions. Consideration within an external mode is more objective. The downside to expressing this in groups is that persons expressing decisions influenced by an internal mode are subject to greater blame, especially when the conclusion reached is not favorable. Conversely, such group members may gain higher ranking if suggestions expressed are found favorable. Communication (often in the form of negotiation) is central in dyadic decision processes (Riggs & Knight,1994). However, individuals often conceal knowledge and personal beliefs for reasons such as fear of being wrong, or suspicions about information offered from certain group members and ignore this information or strain to find information to the contrary.

In decision-making, *Perception* is more powerful than *Belief*. The power of perception causes one to weigh short-term benefits greater than long-term ones (Quattrone & Jones, 1980). Such misperceptions may

result in hesitation or changes in direction during the decision making process. This is even more problematic under conditions of time pressure, dynamic environments, and when multiple individuals are involved in the decision process (Quattrone & Jones, 1980).

Predictions provide beliefs about outcomes (typically future states), sometimes verifiable, and without the requirement of knowledge of a causal mechanism (Rothbart & Snyder, 1970). *Explanations*, by contrast (Smith-Jentsch, Jentsch, Payne, & Salas, 1996), provide understanding, and are rarely directly verifiable but can be evaluated as relatively convincing and clear (assuming the provision of clarifying information in the form of facts). Predictions are often based on explanations, however an explanation may be found by testing a prediction derived from it. Explanations are in some sense easier to produce (in hindsight, by fitting ideas to the data), but more difficult to prove. Explanations are given using a variety of constructs such as theories, models, stereotypes, dispositions, processes and mechanisms, event chains (scripts), and those coming from classical conditioning. Humans are extremely good at representing co-occurrences for events, however this ability causes bias if attempting to detect true correlation's.

The *Plausibility* heuristic (a representative heuristic) or stereotypical fit of an explanation is often mistaken as evidence for its' truth (Smith & Kida, 1991). Plausibility may arise from semantic or conditioned

associations, persuasive arguments, emotional appeals, vivid experiences, or wishful thinking. This can be a compelling influence to humans when the argument offered or association presented appears reasonable

A normative attribution model explanation offered for *Behavior Explanation* (Davis, 1973; Stasser & Davis, 1981), analyzed rules humans use (or should use) when inferring dispositions from others' behavior ('correspondent inferences'). Among these rules are the principles of non-common effects (when inferring a person's disposition, the person must look at those aspects of the chosen behavior which are different from other possible behaviors), and desirable effects (the person may become more confident if he or she behaves in ways that do not bring about generally desirable effects). As a descriptive model of behavior explanation, one of the major weaknesses of classic attribution theory is its assumption that humans explain all behavior alike, namely by way of person and situation causes. However, this dichotomy of casual explanations applies to only unintentional behaviors. By contrast, intentional behavior can be explained by reason, which assumes a conscious choice for behaving a particular way (Nowlis & Simonson, 1997; Sanbonmatsu, Kardes, & Gibson, 1991). Conscious choice is influenced by individual differences such as prior experience and level of situation knowledge, though too often it is assumed that the 'normative' response should be expected (especially during occasions of laboratory research).

Norms are considered past experiences, knowledge, and expectations which provide standards to judge objects or events currently at hand, often becoming standards of comparison (Kaplan & Miller, 1987; Deutsch & Gerard, 1955). However, the standard a person has in current focus when making a judgment is crucial. Norms may best be applied to better understand phenomena in judgment and decision making such as anchoring and adjustment, non-regressive prediction, belief preservation, base-rate neglect, determinants of regret, and the conjunction fallacy.

Whenever predictions are made from several pieces of information (*Prediction Schemas*), a recombination of segments problem is faced. If a global judgment schema is accepted, one looks at all information provided simultaneously and simply makes a prediction (Dunning & Story, 1991). Such single item testing is unreliable as global impressions change frequently. If a component analysis is attempted, each piece of information is considered separately against the outcome to be predicted (Gilovich, Kerr, & Medvec, 1993). This method causes one to give greater attention to individual elements of information.

Humans underestimate medium to high probabilities, and overestimate small ones. Humans are especially prone to overestimate the probability of conjunctive events (worst-case scenarios) and underestimate the probability of disjunctive events (cumulative risks). These types of estimation errors influence our perception of statistics

concerning risky activities (Rothman, Salovey, Antone, Keough, & Martin, 1993). Other known influences are controllability and familiarity. With unknowns, humans maintain extremely strict criteria for safety (McNeil, Pauker, & Tversky, 1988). However, as with EUT, the multiplication costs-benefits and probabilities does not describe our feelings, as a highly improbable but disastrous possible outcome may influence one far greater than might the methodological calculation of an expected risk. Humans also often see meaning in random patterns (*Randomness*), and consider patterns truly random only when they appear absolutely chaotic.

Social Decision Processes are decisions made in social settings, and may be influenced by group member cohesion, isolation, stress, confusion as to agreement on decision-making procedures, and perceived importance of the decision (Bandura, 1986, 1977). Influencing presence's by individual group members may be illusions of invulnerability, or, in contrast, the illusion of unanimity, moral beliefs, and the pressure to conform (Loewenstein, Thompson, & Bazerman, 1989). This may lead to the consequences of failure to criticize most favored options, inadequately surveying alternatives, and poor information search and processing. Group polarization has evolved to what has been termed the "risky shift" phenomenon (Stoner, 1961). Groups shift to either extreme position (greater or less risk accepted) as plausible arguments presented by

influential group members sway others. With this, a pseudo-certainty effect may appear as members become unwilling to consider conditional natures of decisions, and begin to overweight supposedly certain outcomes for assumed probabilistic events.

Antecedents to "Groupthink", where the norm pressure for consensus overrides realistic appraisal or alternative courses of action, are high cohesion, group isolation, directive leadership, high stress, and little agreement on decision-making procedures. Research has shown that decision quality can be predicted by whether or not the group spends time conferring on the decision procedure (Tetlock, Peterson, McGuire, Chang, & Feld, 1992; Janis, 1983; Huseman & Driver, 1979). Symptoms of Groupthink are the illusion of invulnerability, a newly found belief in moral correctness, and acceptance with conforming to pressure (Lord, Ross, & Lepper, 1979). The consequences of Groupthink are incomplete surveys of alternatives, failure to criticize favored option, and poor information search and processing. During *Group Polarization,* experiments have shown groups to shift to extreme positions. A "risky shift" phenomenon, either more risky or more conservative, takes place depending on the initial average leaning of the individual members (Stoner, 1961). This occurs because other persons' unique arguments strengthen one's own position: extreme opinions are more likely to be voiced and thus "pull" others along.

Decision-Making Theory Discussion

Among the myriad of thought given to decision-making theory (DMT), heuristics and biases research has heightened awareness of possible or actual flaws in human reasoning and judgment, though the precise extent to which humans really make mistakes in everyday thinking is unknown (Fischhoff, 1982a; Lichtenstein, Fischhoff, & Phillips, 1982). Moreover, conditions under which heuristics bring success or error have been studied more in the laboratory than in the real world. Some unwanted experimental conditions are unwittingly created by experimenters themselves, as they necessarily limit factors observed. For example, often in decision making research the problem is 'given' to subjects, and only a small number of responses are accepted as correct. In a situation given high demand with minimal information, humans attempt to derive a reasonable answer that depends greatly on personal interpretations of the task demands.

Although the research literature on judgment and choice is voluminous, most posit assumptions (Loke, 1996; Trotman, 1996; Plous, 1993; Arkes & Hammond, 1986). Implicitly or explicitly, researchers continue to make assumptions concerning underlying goals or functions of judgment and choice. The most optimistic theorists (those who neither accept that humans reduce all probability to Baysian calculation, nor

believe recognition priming can occur in every situation) depict persons who relying on lay versions of formal logical, and using statistical procedures to arrive at conclusions (Dreyfus, 1997; Kelley, 1991; Kiesler, 1966). The most pessimistic depict humans as cognitive misers, prone to a variety of judgmental failings (Nisbett & Ross, 1980). There also exist middle-range theories, near the midpoint of the optimism-pessimism continuum, such as those emphasizing the human's capacity to shift from simple to complex cognitive strategies in response to situational demands (Petty & Cacioppo, 1986; Kruglanski & Ajzen, 1983). Another theoretical approach shaping decision-making literature is that of humans as intuitive economists, whose primary goal is to maximize subjective expected utility.

Despite these differences, convergence on one facet remains (Zalesny & Ford, 1990); humans are limited-capacity information processors, relying on inferential shortcuts to help make sense of otherwise impossibly complex environments (Norman, 1985). Heuristics such as availability, respresentativeness, anchoring, and simulation are used to make inferences concerning causality and probability. Humans rely on non-compensatory choice rules to escape dissonant trade-offs. Further, existing knowledge structures are used to interpret new evidence. Unfortunately, the price of such cognitive economy is increased susceptibility to error and bias.

Inaccurate rules may persist because individuals are prone to instinctively search for evidence confirming prior theory (Klayman & Ha, 1987). Such instances are reinforced by 'associationism', the assumption that ideas or sensations experienced at the same time and in contiguity must be associated thus capable of coalescing into complex ideas (Goldstein & Hogarth, 1997). Thus, though expertise is most often considered admirable, how an individual gained expertise may influence situations simply because past experiences may not be completely compatible with circumstances in a present situation. Decision-makers must be trained not only to detect information leading to possible outcomes, they must also learn to question clues in depth considering clue consequence for the current situation.

Classical decision making theory infers a normative and measurable process (Beach & Lipshitz,1993; Beach & Mitchell, 1978), reducing the problem into parts to allow all possibilities considered including the holistic approach of considering all influencing factors, and when used to assess multiple decision events is referred to as 'multi-attribute decision theory'. The emphasis is that errors and biases exist, and that problems are matters of choices between the best possibility of limited errors and avoided biases. Recently re-defined "recognition primed" decision making (Klein, Orasanu, Calderwood, & Zsambok, 1993)

somewhat opposes this thought, appearing to be almost behaviorist in approach to the recognition of patterns.

Models of diagnostic decision-making based on Bayesian decision theory use an information economic strategy (Bayesian probability theory), assigning a fixed quantitative meaning to each piece of evidence based on frequencies derived through assessments made previously (Brenner, Koehler, & Tversky, 1996). In a somewhat similar manner, Skill-Rule-Knowledge based models of cognitive control consider biases and heuristics in attempting to describe or explain the actual process (Rasmussen 1983). In doing so, these allude to subjective probability and utility, attempting to assist decision makers in making the most consistent logical choices.

It is known that expert decision makers under time constraints may not look beyond their sphere of recognition before acting, while non-experts must rely on more analytical processes (Kleinman & Serfaty, 1989). Thus, when forced together in a group, experts and non-experts may experience difficulty developing an adequate mental assessment of the situation, or at a minimum may not come to the same conclusions or do so at similar times during the process (Medin & Edelson, 1988; Montgomery, 1994). Additionally, such instances may require that both experts and novices switch between the individual strategies

aforementioned for making decisions, due to varying constraints of the situation.

For example, one phase of the situation may call for a decision to be made under time pressure while another may not, or the degree of complexity may be limited at a given time though overwhelming at a later period. With this, the extent to which information is not or cannot be known may vary by situation or within phases of a single situation. Even more confounding may be the way in which an individual perceives a situation, which further influences processing. Prior experiences of the decision maker may also have influence, and the expected varying views offered by differing group members (possibly, a result of conflicting processing schemas) may force the group to employ combinations of decision making approaches, leaving additional variable to consider.

Group Specific Considerations

It is agreed that joint team cognition involves more than an aggregate of its members, assuming shared knowledge is an important component for effective performance (Orasanu, 1990; Rentsch & Hall, 1994). Implicit coordination among members must be available in the event that explicit communication is restricted (Kleinman & Serfaty, 1989; Stout, Cannon-Bowers, & Salas, 1996). This shared knowledge is believed by many (Heffner, Mathieu, & Goodwin, 1995; Minionis, 1994; Rentsch,

1993; Stout, 1995; Walsh, Henderson, & Deighton, 1988) to underlie the ability of the team to perceive and act on situations efficiently. Given that the lack of proper communication inadequately conveys a message among members, individual group members would consider complete shared knowledge to be most beneficial. However, complex tasks often require that there be decision-making process periods in which members possess complementary knowledge (homogenous), while other periods require that members provide assistance to the group from backgrounds differing from colleagues. At times, the most favorable situation is a combination of the two. The rationale for this is that as groups are supposedly composed of essential members who each bring unique knowledge to the situation, it would be senseless to assume that all members should possess the expertise of his or her partners (Sundstrom, De Meuse, & Futrell, 1990).

Coordination among group members requires proper communication, as individual differences among members may cause messages to be interpreted differently than intended (Bales & Slater, 1955). Improper interpretation, in turn, causes problems in the synchronization of behaviors, which is especially evident during the coordination and monitoring functions of the decision process. One way in which groups deal with ambiguity due to disorganized coordination is to develop a structure and role specialization. The extent to which a group is

hierarchically structured determines its level of 'centralization' (Shaw, 1964; Shaw, 1976), an important feature of a group. Within formal hierarchical groups, the leader serves as the center of the communication structure (Forsyth, 1990). The leader becomes chief processor of all information, disseminating this among group members.

Thus, the group's structure affects the level of centralization within the group. For certain aspects of the decision-making process such as agreement of a plan of action, a centralized structure is preferable. Given other situations (those in which an individual specialty is required), a decentralized structure is preferred (Milliken & Vollrath, 1991). A centralized structure will be most effective for functions that occur during the implementation stage.

Additionally, group 'cohesion' has traditionally been thought of as a unitary construct, and defined in two ways. The first definition refers to cohesion as "the degree to which the members of the group desire to remain in the group" (Cartwright, 1969). The second definition uses the notion of "resistance to disruption" (Gross & Martin, 1952), where two types of cohesion, social and task, are defined (Zaccaro & Lowe, 1988). Social cohesion is based on attraction to the group due to one or more of the other members (such as friendship or sharing similar personal interests). Another perspective is that task cohesion is based on attraction to the activities that the group performs. The dimension of group

cohesion emphasizes teamwork and a sense of closeness among members, as different sources of cohesiveness serve to strengthen relationships between group members (grouped individuals who posses little cohesiveness should be considered merely an aggregate).

Most groups have some structure governing the interaction pattern among members, and cohesion may affect this (Schater, Ellertson, McBride, & Gregory, 1951). Cohesion is related to performance only when groups establish high performance standards, though this has been debated based on the fact that highly cohesive groups can more effectively enforce group goals. A similar argument is offered, one which states that group drive (the intensity with which individuals exert effort on behalf of the group) moderates the cohesion-performance link (Stogdill, 1972). Only when cohesion and group drive are high is a positive relationship with group performance seen. Groups with high task cohesion have been shown to demonstrate a positive relationship with performance (Carton, 1982; Zaccaro & Lowe, 1988), and such cohesiveness may be a function of compatible member traits.

Models Of Group Decision-Making

The process and archetype by which individuals and groups make decisions has received extensive attention (Hackman, 1987; Kaplan & Miller, 1987; Hirokawa & Johnston, 1989; Poole & Roth, 1989). Theorists

from divergent fields offer differing models depicting the underlying processes and their effect. However, inconsistent conclusions are reached by various theorists. Some researchers (Hirokawa, 1990) emphasize the importance of communication, others (Davis, 1973) highlight the consequence of which alternative the group selects, while still others (Hackman, 1987) consider group structure and social interaction critical for adequate decisions to be made. Such diversified results may be due to the fact that researchers employ individual perspectives when conducting examinations into the decision making process, possibly assuming differing definitions. For instance, Huber (1980) defines decision making as the activities that occur between problem identification and alternative choice; in essence, problem solving as decision making, plus solution implementation.

Kerr (1981), and Stasser and Davis (1981), define decision making as simply the choice of one alternative from a set of many. Hirokawa and Johnston (1989), as well as Poole and Roth (1989), view decision making as a complete process, from problem recognition to solution implementation. Despite the differences in perspective, a common element is that most models emphasize a three-phase approach: 1) problem identification; 2) option generation-selection, and; 3) solution implementation. Poole and Roth (1989) attempted most distinctly to categorize decision model types, identifying three classes: 1) unitary

sequence phase theories; 2) non-phasic theories, and; 3) contingency-phase theories.

Unitary Sequence Phase Theories. Unitary sequence phase theories comprise the largest group of models, possessing primarily two characteristics. First, these assume the group follows a systematic logic applied to required set of activities that must be performed (Tuckman, 1965). For example, though most unitary sequence models arrange sequences of decision making as problem identification, option generations-selection, and solution implementation with different sets of behavior (Dewy, 1910; Bales & Stodtbeck, 1951; Simon, 1960), orientation behaviors (Bales and Stodtbeck, 1951) and intelligence gathering behaviors (Simon, 1960) attempt to capture behavior characteristics during the problem identification phase. Also, unitary sequence models posit decision making as a specific series of phases assuming only one best way to reach a decision without allowances provided for alternating between phases, even if the group finds this necessary to correct an error. Further, unitary sequence theories assume periods of group homogenous activity only, when no member engages in another phase individually.

One of the earliest unitary phase models (Dewey, 1910) and still in use consists of three stages, each asking one question: 1) "What is the problem?" (problem identification; 2) "What are the alternatives?" (option selection), and; 3) "Which alternative is best?" (potential

solutions). Note that a group must first recognize that a problem exists before it can proceed (Moreland & Levine, 1992). The model provided by Bales and Strodtbeck (1951) is similar, possessing an orientation, evaluation, and a control phase, improving upon Dewy's model by including generation and evaluation of potential options during the implementation phase.

Though applicable to a broad range of situations, it becomes difficult to apply theoretical domains to this model as it relies heavily on individual behaviors as opposed to group activity. The idea of three separate phases in decision making continued as Simon (1960) introduced a similar concept for the process, again comprising three phases: 1) intelligence (a search of the environment for information); 2) design (option generation), and; 3) choice (implementation). Such linear views of the decision-making process remain common. Kowitz and Knutson (1980), and later Knutson (1985), highlight state 'characteristics' where: 1) each stage has a distinct theme (Bales & Strodtbeck, 1951, additionally found behavior patterns to be different among phases); 2) each contributes unique information (aggregation of information, solution generation, execution methodology), and; 3) subsequent phases build on the contributions of previous states (one cannot proceed to the next stage until the previous has been settled).

Unfortunately, to assume that decision-makers pass through stages in a linear fashion, especially without repeating or deleting a stage, appears to be an oversimplification (Poole, 1983a). It is also rational to expect a monitoring phase, or sequence during one stage, to assess information gained. It is as well reasonable to provide for a stage at which search for new information is made, prior to proceeding onto subsequent sequences.

Non-Phasic Theories. Non-phasic theories have no discernible phases, and assume decision behaviors to occur dynamically throughout the decision process without periods of homogeneity. This suggests that decision-making is best described as a continuous flow (Seeger, 1983)). Stating that the process is too complex to be explained as simply a series of stages (Cissna, 1984)). In contrast, some research maintains that the process is cyclic (Scheidell & Crowell, 1964), consisting of activity series such as anchoring once one hypothesis is accepted. However, if a fixation is not made, the attention given in considering the cue in question may serve as a clue for the generation of another.

Belief in a non-phasic theory appears reasonable in that group decision-making processes are obviously not entirely orderly (Mann, 1966; Poole, 1981). No compelling model of non-sequenced processes has been constructed to date (Poole & Roth, 1989), thus proven mathematical techniques for assessment cannot be applied. Therefore, no truly viable

theory negating phases has been formulated (Hawes & Foley, 1976; Ellis, 1979; Hewes, 1986).

Contingency Phase Theories. Contingency phase theories argue that no single sequence of phases exists, and allows for periods of unorganized group decision behavior. For example, the model developed by Mintzberg, Raisinghani, and Theoret (1976) contains three facets, with nine sub-facets. The first stage, identification, contains the components recognition and diagnosis. During recognition, problems are recognized which initiates activity. During diagnosis, cause and effect relationships between the observed problem and related variables are addressed. In the second stage (development), solutions to identified problems are generated through active search or the use of preplanned solutions for problems similar (Shaklee & Fischhoff, 1982). The final stage of selection consists of screening (elimination by aspects), followed by an evaluation-choice routine (using either the modes of judgment, bargaining, or analysis only and applying resources to the one option selected). Each stage or sub-component maintains the potential for providing feedback from or reverting to earlier stages.

Mintzberg, *et al.* (1976), found various factors affecting the decision making process, one of which was simple impasse as small problems prevented unitary sequences to proceed to the next phase of decision making. This appeared mainly during implementation phases. Another

influence found was a difference among group members in criterion evaluation, especially when criteria were inconsistent and unclear (Sniezek & Henry, 1989; Sullivan & Kida, 1995). Also affecting the process and found during option selection was that if what was selected did not reach group members desired goals, additional information would be have to be collected. Decision complexity appeared to halt processing when the domain was complex, and extra time would have to be spent acquiring more information and developing feasible evaluation criteria. The development of evaluation criteria was discovered to particularly influence the group decision-making process if organizational demands, and their consequences, were great. Finally, revealed affecting the decision-making process were external influences in the form of resistance to the group's decision. Situations in which outside forces rejected the groups decision sometimes forced the group to begin the entire decision making process again.

Another reasonable approach to determining decision process sequencing (Elion, 1969) requires accepting that the decision making process may not necessarily be taken in order. This approach even suggests it unnecessary for the group to pass through all stages before a decision may be finalized. This model posits eight stages; 1) information input; 2) information analysis; 3) specification of important outcomes; 4) construction of a model of the situation (problem identification); 5)

generation of alternatives for problem solving; 6) the prediction of consequences for each alternative; 7) the specification of criteria for choosing among alternatives (option evaluation), and; 8) resolution of the decision (option selection and implementation).

Eilon's (1969) eight stages of the decision making process can be classified into three tangible though reciprocal phases: 1) problem identification (information input through construction of a model of the situation); 2) option generation-selection (generation of alternatives for solving problem, prediction of consequences for each alternative), and; 3) specification of criteria for choosing among the alternatives, and finally implementation (resolution of the decision). Agreement here acknowledges plausibility for contingent strategies of decision-making

Poole (1983b) supports the proposition that groups do not follow uniform patterns of phases favoring a contingency approach, and suggests that they may only attempt following unitary sequences since these are easiest. However, he realizes that group characteristics and situational constraints often negate their attempts in this, forcing deviations. Mintzberg, *et al.* (1976) illustrates this, supplying evidence of factors disrupting the decision process. Poole and Roth's (1989) contingency model agrees, positing task and group characteristics to affect the decision making process by influencing the sequence of stages. Task characteristics become effective as simple tasks illicit unitary sequences (Tesluk, Mathieu,

Zaccaro, & Marks, 1997), and when given routine problems to solve one or more stages may be omitted.

However, when tasks are complex, the group may be forced to repeat stages. As for group characteristics, the researchers suggest that the degree of cohesion influences the process. Group characteristics (as with task) determine group interaction. As with more complex problems, inadequate group structure causes greater returns to previous stages for problem resolution (Pritchard, Jones, Roth, Stuebing, & Edeberg, 1988; Davis, 1992). Fortunately, increased cohesion allows for better coordination, resulting in decreases in the number of times stages have to be reassessed. This may in all likelihood be true as cohesive groups are more attentive to assigned tasks, and have higher motivation to succeed.

Selection of viable decision solutions requires the generation of a range of alternatives while allowing more individuals to contribute increased possibilities (Beach & Mitchell, 1978). The smaller the set of alternatives, the less likely an acceptable solution is within the set (Fleishman & Zaccaro, 1992). Also of importance is to assess positive as well as negative consequences for alternatives, for if all are not properly evaluated against complete available criteria an improper alternative may be selected (Hirokawa, 1985). There is a greater possibility of accomplishing this when multiple opinions are provided (Gouran & Hirokawa, 1983).

As can be seen, in most models there exists a problem representation phase, as group members must first recognize that a problem exists to initiate the decision making process. It is contended (Flavell, 1979) that this actual acquisition of information process assists in determining the cause of a problem, and factors affecting it. However, this is an on-going process. Individuals continually monitor the environment to enable reaction changes until a problem has been detected, when information search becomes more focused.

Information affecting the problem, such as causes, symptoms, and implications for same, becomes more important, thus members begin to actively seek this information. Researchers consider these activities of greatest importance since they initiate the process, and upon detection the group becomes motivated (Moreland & Levine, 1992). This motivation guides the decision-making process, as the quantity and quality of the information searched and aggregated determines the degree to which the problem cause can be clearly identified and appropriately represented. A problem representation is a mental model of the problem that includes labels, potential causes, and a general idea about what should occur if the problem is not addressed. Differing problem representations lead to different solutions by individual members (Smith, 1989).

When positive evaluations are made, supportive arguments for options are offered, as opposed to negative evaluation which is normally

used to exclude options. Adelman, Gualtieri, and Stanford (1992) found both positive and negative evaluations used more often for options selected than non-reactive evaluations, leading to the conclusion that the amount of evaluation was more important than the actual type (Adelman, Gualtieri, & Stanford, 1992). Once potential solutions are generated, evaluation is based on some set of criteria, comprising a new decision function. For this, the group must determine what is important, suggesting these factors to be problem representation related (Adelman, *et al.*, 1992). Contingent theories provide for via sub-components that offer potential feedback from earlier phases.

During implementation, alternatives selected are put into action, requiring coordination and monitoring. According to Fleishman and Zaccaro (1992), response sequencing is required to order group member actions according to perceived task requirements, and then coordination of member position assuring proper timing. This coordination is the placement of specific activities by group members within a temporal frame, as cues are established for determining when activities should begin and how actions should proceed. Contingency theories allow for this by affording the opportunity to return to previous phases, shifting between these as necessary.

In monitoring effects of the decision, detection of timing, placement, and coordination during implementation of a selected option

afford recognition for the applicability of assumptions made. Such diagnosis and criteria selection allows activation of contingency plans, if found necessary (Payne, Bettman, & Johnson, 1988b). If the decision-making process had followed an simplistic unitary sequence, situational constraints forcing deviations might not have the possibility for correction. Not only do contingency models posit task and group characteristics to affect the process, but these also provide for the omission of unseen cues (missed when presented with simple tasks) and allow options for repeating phases if required (when tasks presented are complex, and the possibility of overlooking information is high). In this manner, contingency models appear to excel in supporting the decision making process (Wilson, Lilien, & Wilson, 1991; Harkness, DeBono, & Borgida, 1985).

Consideration Of Individual Differences

As important as it is to understand the processes by which groups make decisions, it is equally important to understand the individual within group factors affecting functions (Hirokawa & Johnston, 1989). Hackman and Morris (1975) claim that to understand group performance, research must examine three necessary components: inputs, process, and outcomes. McGrath (1984) specified three major classes of inputs to the group, the first being properties of individual members since it is the

ability of individual group members which sets limits on what the group can achieve. A second major input to the group are properties of the group, which determine the structure of interaction among members (McGrath, 1984). Thus, at times it may be necessary that the group be homogenous, however other situations may require specialization of individual operators be highlighted. Task (type, organizational influences, and complexity) and work characteristics (structure, norms, and availability of communication) determine which individual task competencies (knowledge, skills, and abilities to include motivation and attitude) and team competencies (teamwork skills, team relevant knowledge, and attitudes) are required for successful team performance (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995).

Per McGrath (1984), situational variables must be considered an important class input, as the environment affects the way in which individuals behave. For example, under certain conditions (Cannon-Bowers, *et al.*, 1995) some behaviors are appropriate, while this may not be said for others. Steiner (1972) claims group member resources, in the form of knowledge, skills, and abilities, to determine maximum levels of group performance. Likewise, Morris (1975) believes member resource to be determinators for the quality of interaction. To further delineate resource necessities, Simon (1973) proposed a distinction between well- and ill-defined problem solving tasks, while other researchers propose simple

classification schemas (Greeno, 1978; Card, Moran, & Newell, 1983). No matter the classification schema adapted, it is agreed that humans process differently, and this phenomena is not only dependent on past experiences but also affected by inherent traits.

Several studies have analyzed the influence of time pressure and time constraints on decision-making behavior (McGrath, 1990); Ancona & Chong, 1997; Gersick, 1988; Kozlowski, Gully, Nason, & Smith, 1999). These studies identify differing strategies with which humans cope with time pressure and deadlines. Although retaining decision-making strategy, humans may respond to time pressure by reducing the amount of information processed, or by accelerating information processing (Shiffrin & Schneider, 1977). Research has shown humans to filter information necessary to arrive at a decision by focusing on important information and neglecting the relatively unimportant (Ben Zur & Breznitz, 1981). Also discovered was that humans spend less time considering specific individual items of in formation when deciding under time pressure (Wright, 1974).

However, it is important to consider that humans often vary decision-making strategies when confronted with time pressure. In a study conducted by Payne, Bettman, and Johnson (1988a) subjects were asked to decide on various sets of risky options under conditions of none, moderate, and high time pressure. The results of this study led the

researchers to conclude that when confronted with time pressure situations, humans may initially retain their strategy though attempt to accelerate information processing. If acceleration is not found sufficient to cope with the pressure, they may try to filtrate information. Finally, when the pressure becomes extreme, strategy is often changed completely.

Enkawa and Salvendy (1989) developed an empirical model to explain the cognitive processes of human problem solving. Using multidimensional scaling techniques, they found three dimensions to human problem solving and leaning, and two related to the reasoning process. The first dimension, labeled 'top-down/bottom-up', examined a person's attempts to understand a task. A problem solver whose preferred mode is top-down tends to use his or her intuition or insight. This mode of reasoning allows for understanding through the comprehension of general principles and background knowledge. Those problem solvers preferring a bottom-up approach tend to be more inductive in their reasoning (Smith, & Petty, 1996; Laughlin, VanderStoep, & Hollingshead, 1991). Understanding is arrived at through the careful construction of bits of information. Problem solvers using this mode are more likely to generate and test options sequentially rather than simultaneously (Payne, 1992). The second dimension of interest was labeled 'conscious/subconscious reasoning'. At one end of the spectrum are

problem solvers who require conscious thought about the problem, even if to solve it is familiar (Chalos & Pickard, 1985).

Individuals make inferences about available information and engage in some reasoning process, such as *abduction*. Abduction requires conscious reasoning to work through a problem, whether it has been completed before or not. Problem solvers who are near the subconscious end of this dimension are more likely to arrive at the answer to a problem however without being able to articulate how they arrived there. These individuals are more apt to make factually unsupported predictions when confronted with a problem (Vallone, Griffin, Lin, & Ross, 1990). Though the predictions made may be correct, the reasoning leading to these is due to automatic processing rather than a careful consideration of the facts (Dawes, 1993; Yaniv & Hogarth, 1993; Senders & Moray, 1991; Dunning, Griffin, Lin, & Ross, 1990). This second dimension differs greatly from the first in that it taps the knowledge base of the problem solver, while the first considers how information is processed.

Though the affects of differing individual decision style within a group is not widely explored in this manuscript, two scenarios seem likely. First, it is possible that individual group members will adjust their decision style to that of the group leader. This will allow the individual to become part of the leader's 'in' group (Sunderstrom, DeMeuse, & Futrell, 1990). By shifting decision style, group members are able to communicate

effectively with the leader, though they may not be able to easily solve the problem. Differences should be especially acute when the leader's decision style does not match that of the problem before the group. A second possibility is that individuals whose favored decision style matches that required by the problem will be more likely to participate in the group's decision process than will those whose style does not match (Reagan-Cirincione, 1994). The decision style of these group members will be reflected in the amount of information that is collected.

Regardless of the situation, individual traits should affect participation in the decision process, and thus the outcome (Fleishman & Mumford, 1989; Sorrentino, Bobocel, Gitta, Olson, Hewitt, 1988). Given that group performance may logically be affected by individual processing style, it would appear rational to ensure that conflicting member style be avoided when forming a group. For this, some form of theoretical personality assessment must be made, such as is done when employing the "Action Control Scale" posed by Kuhl (1985a). Additionally, this must be done only after a simplistic model of the individual decision-maker has been accepted, such as the model proposed by Rasmussen (1983).

Rasmussen's S-R-K Model. Rasmussen, in his "Skill-based, Rule-based, Knowledge-based Levels of Cognitive Control" (SRK) model, describes different levels of cognitive control used during performance of a task (Rasmussen, 1983; Rasmussen, 1986). Figure 1 shows that the level

of cognitive control used is dependent upon the nature of the task and the decision-maker's degree of experience (Hammond, 1993; Rasmussen, 1993). Information entering via attentional passages is processed at either the *skill-based* level, the *rule-based* level, or the *knowledge-based* level, depending on the operator's degree of experience.

Experienced persons process information at the skill-based level (bottom most level in the figure), as they are able to react to perceptual elements automatically, possibly at a subconscious level. Performance is apparently governed by neurological (level) stimulus-response association. At this level, possible errors are usually caused by misdirected attention (the decision-maker realizes he or she should deviate from habit, however becomes distracted and inadvertently performs the habit). Errors are also caused when the decision-maker gives over-attention to the task causing an interruption, which results in neglect in carrying out necessary automated sequence steps (Ibrahim & Shehata, 1993; March & Shapira, 1992; Gavanski & Hoffman, 1987). One other possible error is that the decision-maker may misinterpret incoming cues.

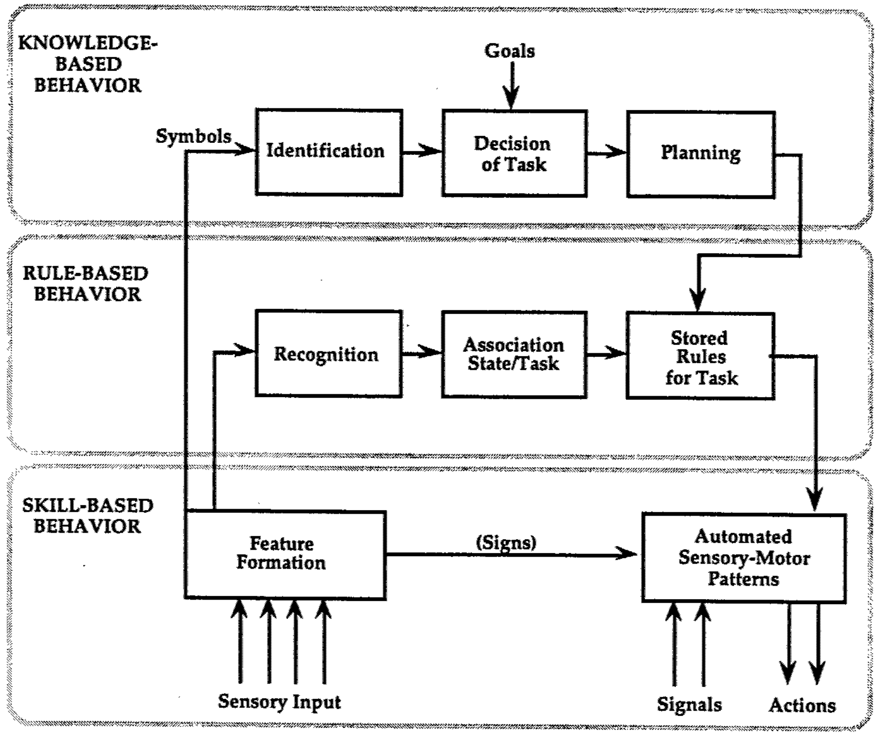

Figure #1. Rasmussen's Skill-, Rule-, and Knowledge-based Levels of Cognitive Control.

Individuals familiar with the task, though lacking extensive experience, process information at the rule-based level (Nosofsky, Kruschke, & McKinley, 1992). Cues recognized (termed 'signs') trigger rules ('if-then' associations between sets of cues, and appropriate actions for these). Such rules are acquired through experience. Decision-making errors at this level are normally the result of improperly classifying a situation, thus applying incorrect rules.

When situations are novel, decision-makers have few rules (gained through previous experiences) available (Payne, 1992), thus essentially perform analytical processing using concept information, and process at

the knowledge-base level. Once meanings are assigned to cues and the situation is identified, the information is assimilated with goals. Unfortunately, in-depth analysis and necessary memory capacity for retrieval to support problem solving and planning cause great effort. This process has, at times, been defined 'problem solving' (rather than decision-making) due to the need for problem definition, solution generation, and the determination of successful courses of action (Bainbridge, 1988). Errors made here may be the results of limited working memory, biases in hypotheses generation, and cognitive fixation (Reason, 1988a). According to the SRK model, a person might operate at the knowledge-, rule-, or skill-based level though switch between them as necessary depending on task familiarity.

More importantly, as persons fluctuate between Rasmummen's levels depending on task familiarity, these levels may also be used to characterize differing degrees of experience. For example, consider a person operating at the analytical knowledge-based level a novice (Hollenbeck, Ilgen, LePine, Colquitt, & Hedlund, 1998; Littlepage, Robison, Reddington, 1997; Rentsch, Hefner, & Duffy, 1990; Zakay, 1985). As the decision-maker acquires a repertoire of rules though experience or training (thus, given a qualitatively different knowledge base), he or she would be considered as graduated to an intermediate operating level, processing at the rule-base. Given a more greatly expanded rule base,

sophisticated knowledge, and with the addition of skills, the decision-maker proceeds to the capability of operating as an expert, processing at the skill-base. However, when an intermediate or expert decision maker is confronted with a novel, unique, or otherwise previously inexperienced situation (during any phase of the decision-making process), he or she may be required to fluctuate or alternate among levels of proficiency to ensure a comprehensive situation assessment and concluding determination. This may require proceeding through analytical processing routines, or considering available decision rules as necessary. However, the personal technique chosen for conduct of this should be expected peculiar to the decision-maker, and influenced not only by previous experiences but also by individual trait.

Decision behavior is sensitive to the number of alternatives existing, to attributes of the alternatives, to the format of information presented, to the context in which this is presented, and to choice set available (Payne, *et al.* 1988b). The human repertoire of strategies for solving problems is limited by individual intellectual capacity (Tversky, 1972), and subject to prior experiences which would naturally include formal training afforded. Since anticipated accuracy of strategy is the advantage considered premium and greatest disadvantage seen as cognitive effort required (Payne, Bettman, & Johnson, 1993), emphasis placed on maximizing accuracy while conserving effort necessitates a

compromise of these, contingent upon the aforementioned limitations. Such compromises necessitate a return to previous stages in the decision-making process to review prior actions, perhaps to consider replacements for those found in question.

Influences Of 'Action' Versus 'State' Orientation

Kuhl's "Action Control Theory". Although a substantial amount of research has shown a high degree of adaptivity in human decision-making behavior (Payne, Bettman, & Johnson, 1993), humans often fail to adapt properly. It is easy to recall situations requiring a quick decision in which indecisiveness became apparent. At times the induction of time pressure increases indecisiveness. The degree to which humans adapt to different task or environmental demands has been shown to be related to the effectiveness with which action control, an individual construct, can be implemented (Kuhl, 1984; Kuhl, 1985a; Kuhl, 1985b; Kuhl & Beckmann, 1994).

From the 1950's to the early 1980's, motivational research was largely guided by the implicit assumption that humans realize their intentions only when they are sufficiently able and motivated (Prussia & Kinicki, 1996; Ilgen & Sheppard, 1997). However, Kuhl (1994) hypothesized that this assumption is not universally valid. Furthermore, learned-helplessness research has demonstrated that persons may display

marked performance deficits despite high motivation and the capacity to achieve success (Ilgen & Sheppard, 1997).

According to Kuhl's (1985a; 1985b) theory of action control, success or failure in implementing one's intentions depends on how effectively action control is readied. Action control comprises volitional processes such as active attentional selectivity (restricting one's attention to the information relevant to the optimal execution of one's intentions), parsimony of information processing (reducing information processing to an indispensable amount), motivation control (focusing on the positive, while neglecting the negative aspects of one's goals), affect control (favoring action-promoting affects, and avoiding action-detrimental effects), and environmental control (such as making social commitments).

The effectiveness with which humans adapt to time pressure is particularly influenced by three volitional processes: 1) active attentional selectivity; 2) parsimony of information processing, and; 3) affect control (Sevenson & Maule, 1993; Wright, 1974). Active attentional selectivity declares that humans prefer intention-supporting information, and at the same time actively avoid information that is inconsistent with their intention. After tentatively deciding in favor of one alternative, humans show a preference for decision-supporting information securing their ability to decide and act, and helping transform their intentions into appropriate actions (Bukszar & Connolly, 1988; Ritov & Baron, 1995).

Parsimony of information processing relates to the definition of stop rules for information processing. Whenever someone believes that further information processing reveals information undermining the motivational power of his or her current intentions, this process brings information processing to a halt (Ackerman, 1998; Kalisetty, Kleinman, Serfaty, & Entin, 1993; Laughlin, Vanderstop, & Hollingshead, 1991; Norman, 1976; Posner & Snyder, 1975). Persons unable to employ parsimonious information processing will often ponder alternatives, even when a preferred course of action has crystallized. Affect control is defined as a volitional process that controls emotional states in order to facilitate the enactment of current intentions, producing hope and confidence while avoiding doubt, fear, and uncertainty.

The effectiveness with which action control processes can be implemented depends on one of two action control modes, 'action generation' and 'state orientation'. An individual is said to be *action-oriented* when he or she focuses on a fully developed action structure, simultaneously or successively paying attention to: 1) his or her current situation; 2) intended future status; 3) the discrepancy between present and future situations, and; 4) at least one action alternative that can reduce the discrepancy. If one or more of these elements are lacking, a person is considered *state-oriented*, where they may be seen to ruminate

about past failure, or take part in wishful thinking fantasizing about an aspired future state (Kuhl, 1994).

Per the theory of action control, a high degree of action orientation promotes the effective operation of action-control processes, facilitating the enactment of one's current intentions. State orientation, due to its dysfunctional attribute of continuing cognition on fixed aspects of a present, past, or future state, impairs efficient action control. Kuhl (1985) maintains that an individual's degree of action versus state orientation depends on both situational and dispositional parameters. Thus, despite situational demands, particular individuals will be especially prone to ruminate about some aspects of the present, past or future state (state orientation), whereas others characteristically focus on the change-promoting aspects of a situation (action orientation) (Kuhl, 1985b).

To assess individual differences along these criteria, Kuhl (1985a) developed the "Action Control Scale" (ACS) (see appendix A). The ACS contains sub-scales with forced-choice items addressing three type of action versus state orientation: 1) failure-related action- versus state-orientation (making plans to reverse past or prevent new failures, versus ruminating about past failures); 2) performance-related action- versus state-orientation (focusing on the activity versus the goal while performing an action), and; 3) decision-related action- versus state-orientation (decisiveness versus indecisiveness). Theoretical work frequently treats

action-state orientation as a unitary underlying tendency, however theoretical and empirical evidence exist for considering the ACS to have both a one- and a three-factor structure (Kuhl, 1994). The items on the scale depict brief scenarios that occur in everyday life, and require the selection of one of two options indicating what the participant would do given the situation presented. Decision-related action versus state orientation, for example, is assessed buy such items in the Scale as follows: "If I had to work at home, I would often have problems getting started" (state orientated), or, "I would usually start immediately" (action orientated), and; "When I want to see someone again, I try to set a date for the visit right away" (action oriented), or, "I plan to do it some day" (state oriented). ("Action Control Scale", Kuhl, 1984)

Action-state orientation is concerned with individual differences in the ability to initiate and maintain intentions (Kuhl, 1994b). The construct reflects the ability to make timely decisions, commit to a course of action, initiate action, avoid procrastination, handle multiple competing demands, maintain challenging goals, and persist despite failures or setbacks (Kuhl & Beckmann, 1994). Action-state orientation not only defines characteristic differences in the enactment and maintenance of goals, but also describes the ability to protect activated goals from competing actions through information-processing mechanisms such as allocation of attention, inhibition of extraneous cognition's, and emotion

control mechanisms (Kuhl, 1994b; Kuhl & Goschke, 1994). This may be useful in understanding why individuals with similar goals, knowledge, abilities, and desire fail to achieve similar levels of performance.

Though studies analyzing the influence of action- versus state-orientation on the effectiveness with which action control processes are implemented have shown action oriented individuals to employ action control more efficiently than state oriented (Stiensmeier-Pelster & Schurmann, 1994; Beckmann, 1994), more specifically these reveal action oriented individuals to: 1) restrict their attention to the information necessary to realize intentions; 2) process information parsimoniously, and; 3) promote action-furthering affects while inhibiting action-detrimental emotions more frequently than state oriented persons. With this, it has been seen that action-oriented individuals (as compared to state-oriented individuals) are more flexible and self-determined in their behavior, and are more able to adapt to changes in their lives.

Several research efforts have analyzed the influence of action- versus state-orientation on decision making behavior, with results supporting the assumption that action orientation is associated more with parsimonious processing of decision-related information than state (Kuhl & Beckmann, 1994; Niederberger, Engemann, & Radtke, 1987; Stiensmeier & Schnier, 1988). However, none of these efforts have analyzed the influence of action versus state orientation as a function of

tasks or environmental parameters, though it is assumed action versus state orientation should promote different responses to at least one environmental parameter, time pressure. According to Payne, *et al.* (1988a), humans show different responses to time pressure. They may accelerate information processing or filtrate information, and if acceleration and filtration are not sufficient they may change their decision making heuristic or strategy. The aforementioned differences in how information is processed under time pressure determines the amount of action control required.

Acceleration processing is a rigid and often inappropriate response to time pressure, and does not demand a substantial amount of action control (Smith & Petty, 1996). Filtration indicates a substantial change in information processing, as important components of available information are processed preferentially and the less important ignored (thus, demanding implementation of the action control processes 'active attentional selectivity' and 'parsimony' of information processing). As parts of the information available are ignored, this filtration of these may cause emotions detrimental to decision-making such as the fear of being inaccurate (Baron, Kerr, & Miller, 1992); Vallone, Griffin, Lin, & Ross, 1990). An even greater degree of action control is required by the third response, changing the decision-making strategy. This necessitates an individual who is highly flexible in her or his behavior, and highly

adaptive to changes in life. State oriented individuals are less able to employ action control, less flexible in their behavior, and less adaptive to changes in life thus should be expected to respond merely by accelerating information processing, whereas those action oriented should respond with filtration or a change in decision making strategy.

Action-state orientations are individual difference variables influencing volitional processes, or what Lewin, Dembro, Festinger, and Sears (1994) refer to as "goal-striving." Goal-striving refers to the process of implementing a goal and reflects a continuous, dynamic interplay of events and cognition's whereby information is monitored over time, and actions are taken based on changing circumstances (Gollwitzer & Brandstatter, 1997; Heckhuasen & Gollwitzer, 1987). In contrast, "Goal-setting" variables are discrete in nature and are not tied directly to task implementation, but rather reflect cognition about the likelihood of achieving a goal. Goal-striving approaches to motivation are more closely related to issues of self-regulation of thoughts and actions (Diefendorff, et al., 1998; Karoly, 1993; Lord & Levy, 1994), similar to action control.

Action oriented persons are able to devote their cognitive resources to the task at hand. These individuals flexibly allocate their attention for the purpose of task execution and goal attainment (Brunstein & Olbrich, 1985). They possess the ability to complete tasks after minor failures or setbacks. State orientated persons maintain ruminative thoughts about

alternative goals, reducing cognitive resources available for goal-striving, and do so especially when the activities are difficult, non-routine, or both (Goschke & Kuhl, 1993; Kuhl, 1981; Kuhl, 1994b).

Three aspects or dimensions of action-state orientation have been delineated (Kuhl, 1994a). First, a 'preoccupation' dimension, which indicates the degree to which individuals explicitly process information related to some past, present, or future state. The action-orientation pole of this dimension (disengagement) refers to the ability to detach from thoughts about alternative goals, while the state-oriented pole is associated with impaired effectiveness due to the preservation of thoughts related to some unpleasant experience. Next, a 'hesitation' dimension, where action-orientated individuals on this dimension (initiative pole) are able to easily initiate work (the preoccupation dimension is concerned with whether distracting thoughts interfere with initiating action, whereas the hesitation dimension emphasizes the behavioral capacity to initiate action). Finally, a 'volatility' dimension presents, which is the ability to stay in the action-oriented mode when necessary, or, conversely the degree to which individuals become distracted.

Action-orientated individuals (persistence pole) are able to effectively maintain focus, while state-orientated individuals are easily pulled off tasks (Kuhl, 1994a). State-orientated processing associated with the volatility dimension may be due to an over activity of the action

initiation system resulting in a tendency to inappropriately initiate new tasks (Kuhl, 1994a). Action oriented individuals flexibly disengage from irrelevant concerns (in other words, they circumvent preoccupation), they effectively initiate required actions (avoiding hesitation), and stay focused until tasks are completed (limiting volatility).

Action-state orientation is a construct relevant to applied settings (Chalos & Pickard, 1985). Holding other relevant individual characteristics such as ability, knowledge, and experience equal, persons more action oriented should complete more assigned tasks, have less difficulty meeting deadlines, and because of their more effective allocation of cognitive and emotional resources to the task produce higher quality outputs. A study by Diefendorff, Hall, Lord, and Stream (2000) observed the relationships between the "Action Control Scale" measures cognitive ability and personality, and determine possible correlation's. The 'preoccupation' sub-scale showed the most consistent pattern of statistically significant unique relationships with the self- focus and self-regulation variables.

Research findings suggest that preoccupation-related action orientation is associated with focusing on both public and private aspects of the self (March & Shapira, 1992; Baars, 1983). The 'hesitation' scale also showed consistent relationships with interference from competing tasks. Significant results of regression analyses for self-focus and self-regulation

variables provided convincing evidence that ACS sub-scales measure constructs relevant to volition or goal-striving, aside from cognitive ability.

Diefendorff, *et al.* (2000) regression models to see if a set of predictors consisting of measures of the Big Five (Barrick & Mount, 1991) would explain most of the variance in ACS sub-scales. Results indicate that the majority of the variance in ACS sub-scales could *not* be accounted for by these measures. Significant indications were that individuals who were more emotionally stable tended to be more action oriented, that more conscientious and outgoing individuals tended to be better at initiating actions, and that being action oriented was associated with socially desirable responding.

Thus, with convincing supportive evidence segmented to each of a three factor solution (preoccupation, hesitation, and volatility), findings imply that action-state orientation is not redundant with existing cognitive ability or personality measures, and indicate action-oriented individuals to stay on task and avoid disruptions superior to state oriented (Gully, 1997). These results are consistent with recent research showing that initiating actions makes competing information less accessible in memory (Gollwitzer & Schaal, 1998; Goschke & Kuhl, 1993). The finding are also consistent with the work of Beckmann (Beckmann, 1994; Beckmann & Kazen, 1994), who suggests that depending on the role and

type of task, a state orientation may be beneficial. Rationale for this is that state oriented individuals, as assessed by the preoccupation sub-scale, may be more cautious, diligent, and thoughtful than action oriented individuals, which may benefit work performance for jobs requiring careful decision making when allowed adequate time to do so.

Both the one factor model (the complete ACS taken as one measure) and the three-factor model (preoccupation, hesitation, and volatility constructs) have the advantage of previous theoretical and empirical validation. Consistent with Kuhl's (1992) suggestion, it may be that volitional constructs assessed by the ACS are more closely tied to actual performance than more distally related constructs such as personality or intellect. It would seem reasonable to consider the possible effects of such personality constructs whenever the necessity for grouping decision-makers arises. Also important are complimentary techniques available, offering assistance to decision-makers in completing tasks. Once such method found beneficial is to employ decision aiding when feasible. Another technique is offer redundant training in quantities as liberal as the situation will allow.

Decision Aiding

A common assist given operators of complex systems are decision aids, employed especially during the problem identification phase of

decision making, however also found a support during the option generation and even solution phases (Mackay & Elam, 1992). Most operator errors arise from a mismatch between the properties of the system and characteristics attributed to human information processing. Complex systems create a situation in which many of the normally adaptive characteristics of human cognition are transformed into liabilities. As this problem is fundamental to the design of many new systems, an immediate (and often permanent) remedy is to provide the human with a cognitive aid to help compensate.

Human cognition is supremely good at modeling the regularities of previous transactions with specific environments, and in using these stored representations as a basis for almost automatic control of subsequent perception and action (Fisk, Ackerman, & Schneider, 1987). It does so with the expectation that recurrences of the past provide a fair guide to the probabilities of the future. Though this may at times be the case, it is usually not true when complex processes are involved. In such systems, the basic task of the controller (the human) is to cope with emergencies and unforeseen situations. Often this may be adequate as humans possess a unique, knowledge-based ability to carry out problem solving in novel situations. However, this is not always the case. One explanation for this dilemma is that human operators under stress are strongly predisposed to use effortless, parallel pre-programmed operations

of stored routines, shaped by personal history and reflecting recurring patterns of past experience (Rohrman, 1986).

Unfortunately, it is in the nature of highly complex processes, especially under stressful situations, that unwanted surprises are uncovered. Each is usually a truly novel event, or concatenations of several prevailing conditions. The literature on accidents accommodates this view by frequently reverting to Rasmussen and Pedersen's (1982) distinction between active and passive failures: the former are operator errors which initiate a major system breakdown, or are committed during attempts to recover from such breakdowns; the latter errors in design, construction, installation, planning or maintenance creating a latent condition ("resident pathogen") within the system (Senders & Moray, 1991; Green, 1990; Reason, 1988b).

Even if it were possible to build an extensive repertoire of recovery routines, there is no guarantee that these would be relevant to all future events (Bignall, Peters, & Pym, 1977; Turner, 1978; Rolt, 1978; Perrow, 1984; Kasputin, 1986). Thus, in the short term, operators must be provided with aids (cognitive aids such as intelligible instruments, shopping lists, diaries, and spreadsheets) to improve their chances of detecting and recovering from errors. Such aids may also provide operators with guidance and a better appreciation of the failure characteristics of complex systems and of basic human error tendencies

(such as the confirmation bias realized when inappropriately sticking to early diagnoses).

By offering decision aiding devices, the tendency to over-utilize the humans' ability to simplify complex information by resorting to pre-established routines, heuristics, or short-cuts may be minimized (Wack, 1985; Hamalainen, 1991). In situations of incomplete sensory inputs, patchy knowledge, insufficient attention to ongoing action, improper or fragmentary retrieval cues from working memory due to preempting stressors (Reason, 1986a; Reason, 1986b), what may often emerge are perceptions, plans, diagnoses, thoughts, recollections, and actions common in previous situations though not relevant to the present. These heuristics, together with 'similarity matching' (relating cues to stored events on the basis of shared features), constitute primitives of the cognitive system. Add to this a pervasive confirmation bias, and the loci for human error becomes evident. As Norman (1985) and others (Hilton & Anderson, 1981; Anderson, 1983; Baars, 1983; McClelland & Rumelhart, 1985) have pointed out, the picture that emerges is of a cognitive system which, though extremely good at internalizing (as stored knowledge) the complexity of the situation currently inhabited, is driven by a limited number of relatively simple computational principles. Providing an aid can only assist the human in circumventing inherent fallacies.

Training For Decision-Making

A substantial body of evidence exists to aid in the design of training programs to assist decision-makers. There also exists a more rigorous scientific basis for continued theoretical and empirical development in the area of training design (Fleishman & Mumford, 1989; Gerstner & Day, 1997); Gully, 1997); Salas, Dickinson, Converse, & Tannenbaum, 1992); Coovert & Craiger, 1997). Recent research emphasizes three factors influencing training design: 1) the phases involved in cognitive learning; 2) the level of learning required for effective performance, and; 3) the tasks being trained. Most often, these are considered in training design for initial skill acquisition and later maintenance.

An early model, proposed by Kirkpatrick (1967), recognized the need for focusing on both learning and behavior when evaluating training for both skill acquisition and maintenance. Successful performance may still depend on factors such as attitude, emotion-focused coping, and motivation (self-regulation) thus almost uncontrollable. However these variables can be viewed in one of two ways. First, if malleable, they may be suitable for manipulation when training. Second, the variables may be viewed as individual difference factors that will affect training outcomes. For example, emotion focused coping may not be trained directly, but the organization may attend to this as criteria for general psychological

functioning in making selection decisions, job assignments, or its decisions about whom to train. When viewed in this manner, these variables are no different from ability variables that apply to any learned skill, thus should be applicable to the skill of making decisions.

Strengthening of a conditioned response takes place through 'reinforcement', which is the military's intent for maintenance training, as non-reinforcement tends to weaken or diminish desired responses (extinction) (Gist, Stevens, & Bavetta, 1991; Marx, 1982; Mausner, 1954). Also, two additional concepts important to consider are 'generalization' and 'discrimination'. Generalization is the process by which novel stimuli produce responses learned to another similar stimuli, where with conditioned 'discrimination' the human can be taught to respond to only one of two cues similar those eliciting different responses. In either situation, for a behavior to be acquired, modified, and sustained it must be reinforced, thus the goals become: 1) to establish or increase the desired response; 2) to eliminate the undesirable behaviors or those competing, and; 3) to ensure newly acquired habits become generalized or self-regulating. In team training, the additional goal is to achieve a maximum sense of environment among members in order to improve intra-group communications and increase flexibility toward innovative reaction (Bass & Vaughn, 1966).

Bandura (1977) determined behavior to be learned from response consequences (reinforcement) and modeling (vicarious or social learning), however this is done through cognitive processes such as representation, interpretation, and recall. Anderson (1982) identified the stages involved in cognitive skill acquisition as: 1) 'declarative knowledge', where trainees learn facts related to tasks, an awkward memory based phase requiring frequent review; 2) 'knowledge compilation', when persons become more adept at recalling information though now must give greater concern to appropriately sequencing steps to be performed thus though improvement is seen mistakes still take place, and: 3) 'procedural knowledge', as performance becomes automated and less effort is required for fact recall or the concern for sequencing (Bandura & Adams, 1977). One caution pointed out in the research performed by Kanfer and Ackerman (1989) is that, during the early phases of learning, ongoing performance suffers when a individuals cognitive attention is distracted from task demands.

Ackerman (1988; 1992), in developing a model of cognitive ability determinants associated with accepted phases of learning, clarified cognitive abilities (verbal, quantitative, and figural) to influence knowledge acquisition during the initial phase of learning (compatible with Anderson's declarative knowledge phase). He suggests that perceptual speed influences learning in an associative phase (consistent

with Anderson's knowledge compilation phase), and that psychomotor abilities influence performance in an autonomous phase as now performance becomes automatic (similar to Anderson's proceduralization of knowledge phase). Again the notion of individuals fluctuating between stages of expertise appears validated.

The emphasis in current training programs placed on coordination among team members, rather than attending to the learning of specific jobs, implies that team training should begin only after individual members have learned their specific duties (Smith-Jentsch, Payne, Johnston, 1996). Conversely, it has been noted that it seems reasonable to assume that individuals learn something about various aspects of team performance prior to concentration on individual training (Campbell, Dunnette, Lawler, & Weick, 1970), in order to properly acclimate to the situation at hand. The two interact. Wiest, Porter, and Ghiselli (1961) found that team performance could be more accurately predicted if it is known how good the most proficient team member is, rather than by knowing the same information for the least efficient member, and; the more similar team members are in their given individual proficiency, the more likely they are to form an effective team once combined.

Concerning post-training methods, Gist, Bavetta, and Stevens (1990) showed the superiority of self-management when compared to goal setting training for improving skill generalization to a different task. In a

subsequent study (Gist & Stevens, 1996), the findings were largely replicated using the approach of mastery versus performance interventions. This latter study also manipulated stress conditions (high versus low stress practice), to discover stress apparently overwhelming training method. A consistent stress-by-training interaction effect was found for skill generalization, where
high stress practice combined with mastery training let to the greatest skill generalization.

Studies that compare pretest measures of performance with measures taken relatively immediately after training on a similar task assess short-term learning or 'initial skill acquisition', teaching general principles is a tenet of training for initial skill acquisition (McGehee & Thayer, 1961). Considering learning retention or 'maintenance' training for learning, Driskell, Cooper, and Moran (1994) found the effects of mental rehearsal to decline by about half when the retention period was 14 days, and after 21 days effects fell below the 10 percent level. Earlier, in contrast, Driskell, Willis, and Cooper (1992) conducted a meta-analysis on the effectiveness of over-learning (deliberate over-training of a task beyond a set criterion of performance), gaining results which indicate over-learning to have a significant positive effect on retention.

Many organizations, including the armed forces of the United States, concur with this suggestion for both 'skill acquisition' and

'maintenance' training, and provide members with redundant training programs to enhance performance and maintain competencies (Ackerman, Kanter, & Goff, 1995; Dwyer, Oser, & Fowlkes, 1995; Mitchel, Hopper, Daniels, George-Falvy, & James, 1994; Ackerman, 1992; Kanter & Ackerman, 1989). The "Operational Risk Management" programs, conducted by the United States Army, Navy, and Air Force emphasizing management (continued redundant reinforcement type training) are such programs deemed quite successful and with a history of positive affect.

HYPOTHESES

Purpose

The present study assessed the effects of training methodology, decision aid usage, and one personality construct, while operating under military situations requiring team (group) decision-making. As this experiment employed "seasoned" operators (military aviation crews), results should augment the knowledge base concerning training and use of decision aiding for determining factors affecting human performance during decision-making episodes, and apply to situations of uncertainty, those which evolve dynamically, and with potentially associated levels of high stress. Recommendations offered should assist in the design of

equipment developed to supplement human deficiencies during episodes of decision making required under imperfect conditions.

Hypothesis #1. All factors manipulated (decision aid, training level, and personality construct as assessed by the "Action Control Scale") will significantly affect performance. It is expected that allowing the use of a decision aid will improve performance, and that providing maintenance training will further enhance performance.

Hypothesis #2. Improved performance should be observed by homogeneous groups, those composed of members with a similar personality construct (measured by the "Action Control Scale").

Methodology

The approach taken was to expose groups consisting of two military combat rotary wing aviators each to three flight scenarios of differing threat severity, requesting that they -- as a group -- assess each scenario prior to flight for potential risks and offer recommendations for alleviation of same. The quality of response, number of possible risks uncovered and mitigation plans provided, as well as the time taken to complete each tasking (scenario), were recorded.

METHOD

Test Participants

Test participants involved were 48 United States Army Cobra attack helicopter pilots. All participants were male between the ages of 29 and 44 (average age 33), in good physical health, and actively pilot or co-pilot the Cobra attack helicopter model 'AH-1F'. Of the participants, approximately 73 percent possessed a bachelors degree (n = 35) with the remainder (n = 13) having graduated high school and successfully completed the U.S. Army Warrant Officer course.

Test participant flight experience, in hours, ranged from a minimum of 500 to a maximum of 12,000 hours, with a mean of 4,910.50 hours. Approximately 38 percent of participants (18 subjects) had achieved military flight times below 2,000 hours, approximately 21 percent (10 subjects) above 2,000 though below 6,000 hours, 25 percent (12 subjects) from 6,000 to 10,000 hours, and the remaining approximate 16 percent (8 subjects) logged flight times of over 10,000 hours. Test participants' held military ranks of Captain (15 participants), Major (14 participants), Lieutenant Colonel (6 participants), or grades three (8 participants) and four (5 participants) of the Warrant Officer classification.

In a previous study (Hirokawa, 1990) with somewhat similar variance to that anticipated for this effort (though with one additional

factor of two levels), for purposes of ANOVA with effect size set at 0.15 and alpha level set at 0.05, power of 0.80 was reached using 24 groups. In the same study, for the purpose of regression where R^2 was set at 0.30, power of 0.80 was also reached. Thus, for the purposes of this study and as recommended by the literature (Kenny & LaVoie, 1985), it was agreed that a similar number of groups might be sufficient.

Materials

Participant Questionnaire. Participants completed a demographics form including information on levels of training and experience. Training and experience were used to classify participants within appropriate groups per experimental conditions (see appendix B). Other demographic information consisted of age, gender, rank, pilot status and approximate time held at this position, and individual training level as this related to the "Operational Risk Management" curriculum or any other felt appropriate. A section of the questionnaire was provided for comments, if any participant chose to make these.

Action Control Scale. The action control scale (discussed earlier in text) consists of three sub-scales: 1) action orientation subsequent to failure versus preoccupation (AOF); 2) prospective and decision-related action orientation versus hesitation (AOD), and; 3) action orientation during (successful) performance of activities (intrinsic orientation) versus

volatility (AOP). Each sub-scale consisted of 12 items describing a particular situation. Each of the item on the Scale had two alternative answers (A or B), one of which was indicative of action orientation and the other of state orientation. For scoring test values, using the action-oriented answers only was recommended, thus the sum of action-orientated answers for each individual scale was between zero and 12.

Risk Assessment Response Sheet. The risk assessment response sheet distributed to test participants was the only method of recording responses required (see appendix C). This sheet consisted of a five level assessment of risk with which subjects were asked to judge the particular scenario in question, categorizing this as to either "low", "greater than low", "moderate", "greater than moderate", "high", "extremely high" risk. These categories are based upon and correspond to United States Naval mishap data provided by the United States Naval Safety Center SPOT Program, and also utilized by the United States Army.

The actual value assigned each cell was devised by selected members of the "Aviation Safety" Programs faculty of the Naval Postgraduate School, Monterey, California based on expert opinion of how "risky" a cell is considered. Tasks were defined based on mission requirements. To elicit less subjective measures, risk assessment rating requested from subjects were compared to parameters set in place under United States Army "Operational Risk Management" teachings (U.S.

Army Field Manual 100-14, 1998; Commander and Staff Risk Management Booklet, 1997), utilizing the categories of 'very low risk' assigned value #1, 'low risk' assigned value #2, 'moderate risk' assigned value #3, 'high risk' assigned value #4, 'very high risk' assigned value #5, and 'not applicable' assigned the code 'NA'.

One exception deals with "rank imbalance" within the cockpit, and this is based on a 10 year study conducted by the Naval Safety Center concerning this phenomena. Differing rank combinations within one cockpit historically have played a part in certain mishap rates, as a pilot with higher rank than another may have attempted to use his or her status to coerce a decision. The value "NA" is assigned when no other risk value is applicable. For example, military flight regulations prohibit low level, contour, or nap-of-the-earth (NOE) flight during instrument meteorological conditions (IMC); therefore, those values should be listed as "NA" in their corresponding risk cells.

Also provided on this sheet were areas for identifying possible risk in the scenario (beginning with the statement "To avoid or alleviate a possible mishap concerning..."), and areas for offering considerations for remediating the risk identified (beginning with the statement "I would recommend the following..."). From the latter subjective question it was felt that most pertinent information, that relating to good or poor performance, could be seen once interpreted. Finally, the initial risk

assessment was timed, thus a section for recording exercise start and stop times was placed on the assessment sheet.

Pre-Flight Checklist. A pre-flight checklist, adapted from the U.S. Army's "Rotary Wing Assessment Value" worksheet, though modified to include only information essential to the effort in question, was provided to one-half of the participants (see appendix D). This check-list comprised the 14 categories of potential risk to include relationships to mission completion, planning, and complexity, additional factors which may normally be anticipated given a military flight, the potential risks of weather, night illumination, and pilot and co-pilot previous flight experience. Also included were questions concerning experience with the particular aircraft, risk due to fatigue, and the total amount of and most current experience with night vision devices. Finally, provided on this checklist were the "Five Step Risk Management Process" guidelines, and "Basic Rules of Risk Management" steps for reference.

Task Scenarios. Three flight scenarios of varying degrees of complexity were provided to each group of two participants, ranging from expected average to fatiguing to adverse conditions. With this they were expected to return assessments as to the risk involved. Scenarios were written in the form of operations orders, which military pilots are quite familiar with (see appendix E, with scenario descriptions).

Experimental Design

This is a $2 \times 2 \times 3$ repeated measures design, with two between-subject levels of the independent variable *training* (level #1 -- 'awareness', and level #2 -- 'maintenance' "Operational Risk Management" training), two between-subject levels of the independent variable *decision aid* (either an aid provided, or operating without), and three within-subject levels of *risk* (scenario). Group homogeneity (variable name *homogen*), a covariate assessed by evaluation of one personality construct, was considered a continuously distributed subject level variable, comprising one quantity though possessing three components, and addressed *post hoc*.

<u>Independent Variables</u>. Independent variables manipulated consisted of: 1) whether participants were allowed the use of a printed pre-flight risk assessment decision *aid* (see appendix D) versus not allowed the use of one; 2) type of *training* participants had progressed through, "Operational Risk Management" 'awareness' training only, or both 'awareness' and 'maintenance' training for this curriculum, and; 3) the degree of *risk* exposed to by given scenarios (see appendix E). Group composure, determining homogeneity or heterogeneity of membership and assessed by the measurement of one personality construct, was observed as a continuous within-subject level covariate.

<u>Experimental Conditions</u>. For manipulation of the independent variables, groups were formed as follows: 1) groups of two participants

each consisting of individuals having had "Operational Risk Management" 'Awareness' training only, and these tested when allowed the use of a Decision Aid; 2) groups consisting of individual test participants having had "Operational Risk Management" 'Awareness' training only, and these tested when *not* allowed the use of a Decision Aid; 3) groups consisting of individual test participants having had "Operational Risk Management" 'Awareness' training *and* 'Management' training, and these tested when allowed the use of a Decision Aid, and; 4) groups consisting of individual test participants having had "Operational Risk Management" 'Awareness' training *and* 'Management' training, and these tested when *not* allowed a Decision Aid (see Table 1).

Table #1. Test participant Variable Level assignments.

Training Level #1		Training Level #2	
Decision Aid *"Yes"*	Decision Aid *"No"*	Decision Aid *"Yes"*	Decision Aid *"No"*
group 7	group 10	group 1	group 4
group 8	group 11	group 2	group 5
group 9	group 12	group 3	group 6
group 19	group 22	group 13	group 16
group 20	group 23	group 14	group 17
group 21	group 24	group 15	group 18

Dependent Measures. Dependent measures information collected was a quality value for risk mitigation options generated, and combined

risk assessment and contingency plan generation time. The contingency 'response value' rating was produced by applying the following sequence: 1) determine the number of risks uncovered by test participants per individual group; 2) sum these per importance of weight assigned each by subject matter experts to determine a raw score 'risk value'; 3) list the number of risk mitigation contingency plans provided by participants for the aforementioned risks; 4) sum these per weight assigned each contingency to determine a raw score 'contingency value'; 5) multiply summed 'risk values' by summed 'contingency values' to determine a total 'risk by contingency' value per individual group given the scenario in question, then; 6) divide this sum by 100, as the following displays:

$$\Sigma\,[(\text{weights of risks uncovered})\ x\ \ (\text{weights of mitigation contingeny plans})]\ /100$$

The 'response value' reflects whether participants represented the problem posed correctly, had adequate knowledge of the situation they had been put in, and were fully aware of associated ramifications for their decision choice to include errors made in the form of potential though overlooked flight mishaps. This basically consists of detecting hazards, discriminating friend or foe, and planning for the unforeseeable.

The 'times' to complete assessments (a dependent variable) was computed by summing the time recorded for participants to uncover

possible risks in a given scenario with the time taken to develop contingency plans for mitigation.

Response Score Calculation. All participant responses were input to a word processing file, and after screening redundancy eliminated. The remaining responses were then presented for evaluation of quality to knowledgeable persons. For this, two subject matter experts, both military aviators, one currently teaching and the other having had taught and enforced "Operational Risk Management" procedures for the armed forces of the United States, were tasked with weighting significance.

At this point, possible risk conditions and contingency plans for risk mitigation were classified by subject matter experts into distinct agreed upon circumstance categories, and assigned an initial category importance weight determined individually for the three scenarios presented (out of a maximum 100 percent). This allowed reduction of the subjective data, providing experts with only subsets of categories to focus on. The resultant possible risk and mitigation recommendation category subsets resolved were: 'weather', 'flying', 'fatigue', 'navigation', 'visibility', 'enemy', and 'inexperience', or combinations of these. Once experts had agreed upon subsets, each test participant provided risk and contingency was classified under one of the aforementioned sets. Now categorized, the remaining (non-redundant) identified risks and contingency plans submitted by participants were weighted as to their degree of importance

given the scenario, however within the percentage limits defined by their respective category. This process provided a template for use reducing bias when evaluating group performance.

The preceding was performed in an attempt to ensure inter-rater reliability when assessing test participant subjective responses (assuring that response attributes conveyed similar meanings to separate observers), and describes a form of "Attributional Coding". This provided a quantitative method, where written perspectives concerning risk and mitigation for same per test scenario (participants subjective responses) could be 'coded' concerning relevance to the situation as agreed upon by experts, rendering quality scores in percentages. Though attribution theory formally concerns causal explanations which people produce when encountering novel, important, unusual or potentially threatening behavior and events (Baucom, 1987; Weiner, 1985; Wong & Weiner, 1981), applied to the current situation this technique allowed qualitative material to be encoded using a pre-specified frame, permitting statistical analysis and consequent comparison across groups. As such, necessary content analysis of verbatim information could be identified, reduced, extracted, and quantified reliably (Schulman, Castelon, & Seligman, 1989).

To further ensure weightings did not unduly reflect either subject matter experts desire or idiosyncratic personal view (in other words, to observe how well or poorly raters agreed), percentages of agreement (the

measure of reliability) were computed and assessed by use of Cohen's kappa (Cohen, 1960). Note that given a particular coding schema or recording strategy some agreement should occur by chance alone, and though simple agreement percentage scores could have been computed these would not correct for chance. Cohen's kappa, a summary statistic, possesses the advantage of chance correction by describing agreement with respect to how a coding schema is or will be used, and is defined as follows:

$$K = \frac{P_o - P_c}{1 - P_c}$$

In the equation, P_o is the proportion of agreement actually observed, and P_c the proportion expected by chance. P_o is computed by summing the tallies representing agreement (between raters), and dividing by the total number of tallies.

To determine if a given value of kappa differs significantly from zero, Fleiss, Cohen, and Everitt (1969) described the sampling distribution of kappa. The population variance for kappa (assuming kappa zero) is estimated from the sample data, and the value estimated divided by the square root of the estimated variance. The result is then compared to the normal distribution. Fleiss (1981) characterized kappas of 0.40 to 0.60 as fair, 0.60 to 0.75 as good, and above 0.75 excellent. Once agreement at a

detailed level has been established, this may be assumed at less detailed levels. For the current effort, all resultant kappas were within the limits of reasonable acceptance. Cohen's kappas regarding risk assessment for scenarios #1, #2, and #3 were 0.91, 0.80, and 0.85 respectively. Those resulting from assessment of contingency plans produced by participants were 0.87, 0.78, and 0.81 respectively.

In support for use of this method, Gottman (1980) states that if independent observers produce similar indexes of generally sequential connection between codes, then reliability has been established. Thus, the method of assessing data derived from two observers in agreement while independently coding the same stream of behavior is expected to yield similar conditional probabilities. Additionally, Cohen's kappa is agreed upon as a statistic appropriate for use in demonstrating point-by-point agreement (Hollenbeck, 1978; Hartman, 1977, 1982). As subject matter expert observations of critical team behaviors was employed since these pertained to results of task performance, these may be accepted as inferences concerning dimensions such as adaptability, coordination, and communication (Glickman, Zimmer, Montero, Guerette, Campbell, Morgan, & Salas, 1987; Morgan, 1986), supplemented by less subjective measures such as time to complete the decision making tasks.

Statistical Analyses. The initial analytical proceedures followed were the submittion of data to ANOVAs for association of subject

responses with affecting factors, followed by appropriate *post hoc* comparisions made to ascertain significance and loci. Subsequently, ANCOVAs were used to compare groups formed by categorical independent variables on differences in individual dependents, as one independent was predictably found correlated with two others. This method tested the direction and size of possible correlation.

Multiple regressions on separate dependent variables were preformed, with the added step-wise induction of one continuous individual predictor (the personality construct) to determine 'weights' (significance) for found effectors, and to predict variance (*b*, the regression coefficient representing the amount dependent variables changed as independents were altered, was standardized to 'beta weight' so as to determine a ratio of coefficients for relative predictive power of independents). R^2, the multiple correlation, was observed to determine the percent of variance in the dependent explained collectively by all independents, as is appropriate when introducing additional predictor variables.

To uncover degree of and subsequently partition covariance between the factors *training* level (levels #1 and #2) and pilot general flight "experience" (measured in flight hours) to determine significance of either, ANCOVA was preformed partitioning out covariance for experience.

Procedure

Testing was conducted in mobile offices, and occurred over the course of five days. Each test session took approximately four to five hours to conduct, and preformed during morning hours only. Test participants were scheduled sessions per instructions given to them by their unit commander.

Participants initially sat where they pleased upon arrival, and at that time were informed the nature of the test and the extent to which they would be asked to participate. Participants were told that if they agreed to participate, a completed and signed volunteer consent form was necessary. No participant declined. After completing the consent form, further explanation of the purpose and importance of test results was offered, and questions answered. The participant questionnaire was distributed, with instructions for completion given. Responses from the questionnaire determined which groups individual participants would be assigned to. Given the level of experience per subject, no further training was deemed necessary other than for testing instructions and statements concerning test conduct.

After completion, the questionnaires were collected for a review of participant training experience (for group assignment), and while this took place participants were handed the "Action Control Scale" for completion.

Prior to distributing this Scale, participants were informed of what this information would be used for, and specifically encouraged to answer honestly. Here, the test director mouthed the statement "Please be as 'critical' of yourself as possible.", to ensure that each participant would respond to questions truthfully (a necessity for the success of this tool). While the Scale was being completed, the test director reviewed participant questionnaires, and made group assignments.

Participants were identified on all forms only by a number assigned. Once the "Action Control Scale" was completed testing began. The tasks presented to participants were to review three military flight scenarios (written in the form of military operations orders), and, after which, make pre-flight risk assessments for each indicating possible risk conditions, recommending methods for avoidance, and offering contingencies for the alleviation of potential risk.

Scenarios were distributed one at a time, and their order randomized throughout the five days of testing so that no group received these in a similar sequence as any other another. During the first session, Scenarios were distributed in the order Scenario #1 first, then Scenario #2, and then Scenario #3. During the second session, the distribution order was Scenario #2, #1, and #3. Distribution during the third session was in the order of Scenario #3, #1, and #2. The fourth session distribution order was #1, #3, and #2. And finally, the distribution order used for the last

session was Scenario #3, #2, and #1. The entire test session was divided in thirds per each Scenario given, and adequate time allowed for subjects to complete the task. Completing each third of the total test took approximately one and one-half hours.

Complete testing sessions for each of the scenarios were divided by: 1) a timed risk assessment period where participants were asked to uncover possible risk situations in the scenario presented them, and; 2) a second timed period, used for participants to list remediations to risks found while working with and after discussion with their group partner. Subjects were placed in groups of two participants each, using the guideline of level of training received (similarly trained subjects were placed together). Prior to distributing each scenario participants were instructed as to what their task would be, and that they were only to work with their (one) group partner. Test administration assistance from two auxiliary personnel (two military officers, not involved in taking the test) was offered the test administrator, and these persons were asked to observe subjects and to record how often the groups who had received the checklist were utilizing it.

After participants had completed each scenario and concluded with the risk assessment data sheet, these were collected and collated. Following this, instructions and materials for the test scenario required next were distributed, and the process continued until all scenarios were

complete. After tests were completed, a debriefing session was held in which participants asked questions they may have had, were informed that they may expect a copy of results if providing the experimenter a personal mailing address, and then were released.

Variable Rationale. As Baker and Salas (1992) remark that team process measures unfortunately rely heavily on observation, though to provide independent onsite observers is often impracticable. Further, it is important to consider that teams evolve, thus skill levels change as the team matures (Morgan, *et al.*, 1986). This necessitates that teams be observed during a variety of conditions to avoid recording only those teamwork skills influenced by a particular situation. Conversely, in stating the importance of team work measures, Dyer (1984) warns researchers to avoid complex and insensitive measures as well as irrelevant variables. In an attempt to comply with recommended data collection procedures during the present effort, concern was placed on the quality of final decision results with additional measurement taken for times to reach decisions (of both risk assessment and to develop plans for risk mitigation).

Fowlkes, Lane, Salas, Franz, and Oser (1994) delineate behaviors viewed essential in establishing coordination among individual team members to achieve common goals as: 1) mission analysis (defining tasks based on mission requirements, devising long- and short-term plans,

identifying potential impact of unplanned events, and structuring tasks, plans, and objectives); 2) adaptability or flexibility (altering plans to meet situational demands); 3) situation awareness (noting deviations, recognizing the need for action, demonstrating ongoing awareness of status), and; 4) final decision making (gathering pertinent data, identifying alternatives and contingencies, and anticipating consequences of decisions).

Given the preceding, it was expected that data collected should allow inferences made to several of the teamwork skill dimensions as described by Cannon-Bowers, Tannenbaum, Salas, and Volpe (1995), being: 1) adaptability (the process of using information from the environment to adjust strategies, reallocating team resources), showing flexibility (the development of innovations); 2) shared situational awareness (comparing models of the environment, reaching a common understanding) as the team gains greater system awareness; 3) performance monitoring (error identification, strategy development, and procedure maintenance); 4) team management allowing task structuring (delegation of assignments, resource distribution and management, and the establishment of priorities), and performance monitoring (for mission analysis); 5) development of interpersonal relations (resolving member conflicts); 6) coordination of task organization (coordinating task sequences, and integration of same), and task timing or pacing; 7) communication to

provide information exchange (information sharing), and necessary consulting (to exchange relevant interpretations and evaluate the situation) to achieve group awareness, and; 8) decision making for problem assessment and solving (the emergence of solutions, determination of probabilistic structure, hypothesis formulation, information processing and evaluation), planning (plan development and use of information), and implementation.

RESULTS

The dependent variables 'response value' and 'times' were assessed for influence by *training* level, use of a *decision aid,* and *risk.* A fourth independent variable, group homogeneity (variable name *homogen,* an individual construct), was found to be correlated with both the *training* level and decision *aid* (discussed later in text), thus inappropriate for inclusion as a covariant in ANOVA (Olson, 1976).

Response Value. The overall mean for 'response value' was 7.857 with a standard deviation of 5.653. The minimum score recorded was 0.90 and the maximum 22.8, giving a range of 21.9 with median of 6.02. ANOVA results for 'response value' revealed significant main effects for all three independent variables. Participants who had

completed training level 1 had a mean response value of 4.35 compared to those that had completed training level 2 with a mean RV of 11.36, $\underline{F}(1,20) = 399.75$, $p < .01$. When a decision aid was available, the 'response value' higher (M= 10.28) than when it was not available to participants (M= 5.43), $\underline{F}(1,20) = 185.815$, $p < .01$. A main effect $\underline{F}(2,40) = 45.34$ $P<.01$ for the *risk* per scenario was also found, as shown in Figure 2. Apparently, the increased risk presented during scenarios #2 and #3, as compared to scenario #1, had a significant effect on 'response value' (i.e., lowering performance).

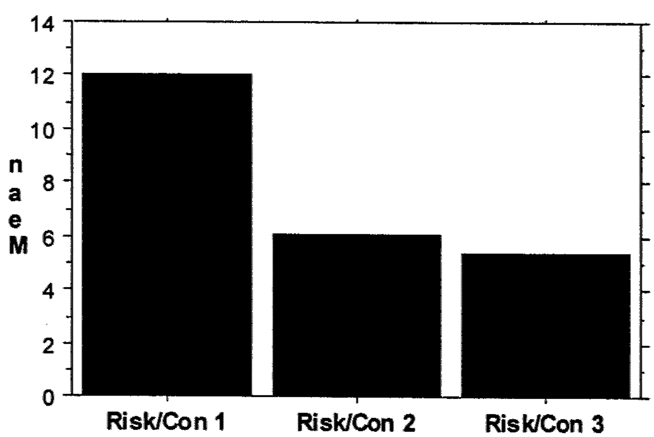

Figure 2. Plot of 'Response Value' by Scenario.

A statistically significant interaction between training and decision aid was also present, $\underline{F}(1,20) = 54.98$, $p < .01$. As indicated in Table 2, 'response value' increased as a function of both *training* level and decision *aid* usage. At training level 1 (the lower of the two

training levels) and without the use of a decision aid, the group mean (score) reached 3.239. However, when a decision aid was used with this same level of training, the mean increased to 5.648. At level 2 training (the advanced training level) but without a decision aid, the mean was 7.817. With level 2 training and given a decision aid to assist, the group peaked at a mean 'response value' of 14.724. Table 2 shows that the *decision aid* produced slightly larger 'response value's for training level 1, but much larger gains in 'response value' for training level 2.

Table 2.
Means Table for 'Response Value' by Condition.

	Count	Mean	Std. Dev.	Std. Err.
Training Level 1, without Aid	18	3.239	1.841	.434
Training Level 1, with Aid	18	5.648	3.167	.746
Training Level 2, without Aid	18	7.817	3.449	.813
Training Level 2, with Aid	18	14.724	5.518	1.301

There were also significant interactions between *training* and *risk/scenario* and between *decision aid* and *risk/scenario*. The effect of *training* combined with *risk/scenario* may be seen more clearly in Figure 3. Performance of participants trained level #1 was lowest overall. More importantly, an eight point difference may be seen between *training* levels #1 and #2 during the second condition, where only a three point difference exists among these levels during the third condition.

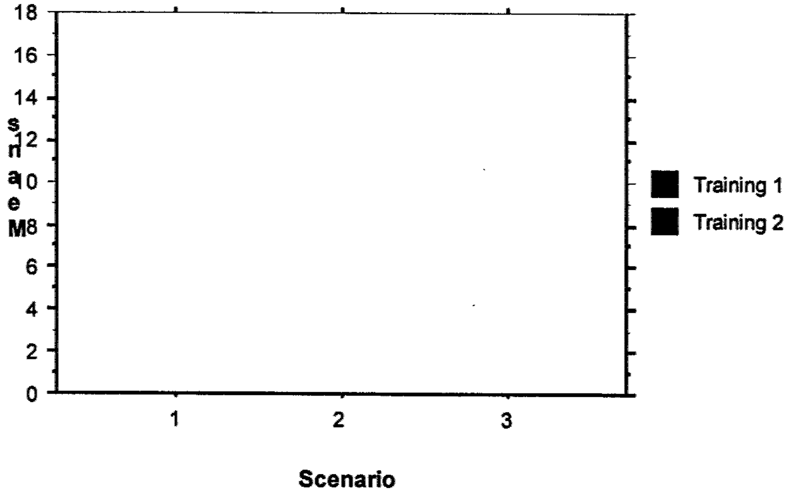

Figure 3. Interaction between *Risk*/scenario and *Training*.

The interaction found between *risk/condition* and *decision aid* was also significant, F(2,40) = 14.02 P<.05. Table 3 shows a larger *aid* effect for the first condition over the second and third, suggesting the benefit of the decision *aid* not uniform across all risk conditions.

Table 3.
Confidence Intervals of Decision *Aid* by Condition for 'Response Value'.

		Mean	Std. Error	95% Conf. Int. Lower	Upper
Aid 1	Con 1	8.396	.434	7.487	9.304
	Con 2	3.837	.398	3.003	4.671
	Con 3	4.055	.393	3.223	4.878
Aid 2	Con 1	15.768	.434	14.860	16.677
	Con 2	8.416	.398	7.583	9.250
	Con 3	6.669	.393	5.846	7.491

Response Times. Though task completion times were recorded, this information was not of foremost interest. The usual procedure

followed by military during pre-flight risk assessment is to allow adequate time for planning, as once the mission begins there may be little time to reflect on possible contingencies that should have been addressed prior to departure. Normal pre-flight risk assessment times are usually more than one hour, though less than two. Participants were allowed one hour to complete each of the three scenarios. None of the pairs of participants required more than the allotted time.

The overall mean for the dependent 'times' was 31.5 minutes taken, with a standard deviation of 8.4 minutes. The minimum time recorded was 13 minutes and the maximum 51.5 minutes, giving a range of 38.5 minutes with a median of 30. The only significant finding for time was between the levels of the independent variable *decision aid*, $\underline{F}(1,20) = 43.99$, $p < .01$. No significant interactions were observed between independents.

It is apparent that use of a decision aid increased group time to respond, as revealed by the varying group means for this factor. Though 'times' did increase slightly as a function of the level of *training* afforded, *decision aid* usage led to far greater increases in time. At *training* level 1 and operating without the advantage of a decision aid, the mean group time recorded to complete tasks was 25.819 minutes. At the same training level though with a decision aid, the mean task completion time increased to 40.014 minutes (35 percent

higher than those not allowed use of an aid). At training level 2 without use of a decision aid, group mean time was 24.083 minutes as opposed to the higher 36.08 minutes recorded with decision aid.

Group Homogeneity. A third subject level independent variable, group *homogeneity* (variable name "*homogen*"), an individual construct measured by the "Action Control Scale", did not reach a level of statistical significance in analyses. As stated earlier, group homogeneity was found to be correlated with both the *training* level (R = 0.454) and *decision aid* (R = 0.476) independent variables, thus would have been inappropriate for inclusion as a "factor" in ANOVA. This independent produced a mean of 15.485 along the scale used, with a standard deviation of 11.348. The minimum scale score recorded for any group was 1 and the maximum 37, giving a range of 36 with a median of 12.

Unfortunately, the degree of covariance for the group homogeneity variable *homogen* causes a dilemma in that this factor does appear to have an effect on performance. The independents *training* and *aid,* which did reach statistical significance, were entered into the statistical computation program as nominal variables (as these are nominal). The third independent, *homogen*, was entered as continuous and intended as a subject level continuous variable. Under further scrutiny using separate ANCOVAs, homogeneity as a covariate

of the factors *training* and *aid* may influence the dependent 'response value' if observed in isolation as $\underline{F}(1,68) = 5.734$, $p < .0194$ and $\underline{F}(1,68) = 7.892$, $p < .007$ respectively, thus should be addressed. This factor performed similarly as a covariate of *training* only in effecting the second dependent 'times' as $\underline{F}(1,68) = 9.161$, $p < .004$.

It had been considered that pilot experience (measured in flight hours) may account for partial increase in 'response value' (performance), over and above the effect realized by the independent variable *training*, especially for level 2 of this variable. In response to this, the test participant population was divided by experience in flight hours. The mean of all flight hours was 4910, with a minimum of 750 and a maximum of 10,000, giving a range of 9,250 and median of 4375 hours.

After sorting to ensure equal numbers of participants into groups from both levels of training, what remained was one sub-group accounting for 59 percent of the total participant population (possessing flight hours of from 500 to 5,100), and a second consisting of the remaining 41 percent of the total participant population (having accumulated from 6,250 to 12,000 career flight hours). The data compared was participant 'response value' results for the effect of the independent variable *training* using flight hours (experience) as a

covariate, to find *training* significantly effecting the dependent measure as $\underline{F}(1,68) = 11.727, p < .001$.

The effect of the variable *training* over and above pilot flight experience may be seen more clearly by examining individual scenarios, as the more challenging scenarios #2 and #3 differed significantly from the less taxing scenario #1. Though the level of training attained may not have influenced participants during the less taxing scenario #1, this aspect did have an effect when situations became more intense.

Finally, to determine if any (or all) independent variable(s) would serve as predictors of performance, data was submitted to multiple Regression analyses beginning with the first, and of greatest concern, dependent variable 'response value' (the quality of final risk mitigation plan submitted by test participants). This analysis revealed that 54.5 percent of variance in the dependent 'response value' could be explained collectively by the three independents *training* level, *decision aid* usage, and scenario risk. Thus, combined independent variables are capable of significantly predicting over one-half the variance in this dependent measure.

Individual regression coefficients (see Table 4), representing the amount the dependent 'response value' changed as independents change (one unit), were 6.437 for the independent *training* ($p < 0.0001$),

4.249 for the independent *aid* (0.0002), and 0.039 for the independent *homogen* ($p > 0.05$). Thus, for mean 'response value' attained by test participants grouped along the level of training, the factor *training* is obviously a strong predictor (beta weight of approximately 57 percent, partial correlation of 0.608), followed by use of a *decision aid* (beta weight of approximately 38 percent, partial correlation of 0.415). As expected, the independent *homogen* did not fare well as a predictor, as the majority of variance could be accounted for by the previous predictors.

Table 4.
Regression Coefficients Table for 'Response Value', Predictors *Training, Aid, Homogen.*

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	-8.770	2.175	-8.770	-4.032	.0001 ***
Training	6.437	1.072	.573	6.005	<.0001 ***
Aid	4.249	1.086	.379	3.912	.0002 ***
Homogen	.039	.055	.076	.704	.4836

For the dependent variable 'times', the percent of variance in the dependent explained collectively by all independents resulted as 0.649. Combined, the independents are capable of significantly predicting almost 65 percent of the variance in this dependent.

Individual regression coefficients (see Table 5), representing change in the dependent 'training' per unit of change in independents, were –2.243 for the independent *training* ($p < 0.114$), 13.717 for the

independent *aid* ($p < 0.0001$), and -0.059 for the independent *homogen* ($p < 0.417$). Thus for mean 'times' taken by participants to complete task, the factor *training* in this study (though not a significant predictor of performance) apparently had slight negative influence (beta weight -.134, partial correlation of –0.170), while use of a decision *aid* (beta weight of over 80 percent, partial correlation of 0.785) was obviously a very strong predictor.

Table 5.
Regression Coefficients Table for 'Times', Predictors *Training, Aid, Homogen.*

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	15.194	2.841	15.194	5.348	<.0001 ***
Training	-2.243	1.400	-.134	-1.602	.1138
Aid	13.717	1.419	.822	9.668	<.0001 ***
Homogen	-.059	.072	-.078	-.818	.4165

Assessed individually, the independent *homogen* would have minimal degree of predictive power ($R^2 = .267$).

DISCUSSION

The current effort examined influences on decision-making performance among pairs of individuals concerned with personal risk, while involved in military aviation exercises. United States Army attack helicopter aviators were divided into groups and exposed to experimental

conditions in which a printed decision aid was either provided or not during testing, and further grouped by either of two levels of formal pre-flight risk management training which they had previously undergone. This arrangement was made to determine the possible effect and interactions of decision aiding and type of training across three different scenarios (which varied in the level of risk). In addition, the effect for group homogeneity on performance was tested, where homogeneity was based on Team member's congruity on Kuhl's "Action Control Scale" (Kuhl, 1985).

Tasks consisted of pre-flight risk assessments made by participants for flight scenarios varying in risk severity. As the situations presented required simultaneous cooperation, it was assumed that teams performed decision-making tasks in a manner comparable to that which might normally be expected, as has been done in the past (Merket, Bergondy, & Salas, 1999).

Of two hypotheses tested, the first could be supported, however the second could not. The first assertion made was that all factors manipulated would significantly effect performance, and that the level of difficulty per task presented (three varying levels of risk in all) would be reflected in the degree of performance recorded. Specifically hypothesized was that participants allowed use of a decision aid would demonstrate better performance over their counterparts not offered use of an aid, and

performance would be found superior by those having had an the advantage of advanced training. Improvement in results should be realized by groups composed of members similar in personality construct, according to 'Action Orientation' characteristic theory.

The data assessed were composites of counts and degrees of hazards addressed for the appropriateness of risk mitigation contingency plans submitted, and done for three conditions presenting varieties of risk from low (e.g., excessive fatigue) to high (e.g., risk as a result of military conflict). The intent was to elicit final responses, agreed upon by both within group members, exhibiting a best attempt at characterizing situations ranging from mere hazard avoidance to the potential concern for life preservation.

Manipulation Effects

Training. As expected, the advantages of providing advanced *training* could easily be seen. This became especially apparent as tasks increased in complexity and degree of risk. The first flight scenario (task) presented to participants was one of routine, low risk. During this condition, having had increased 'Operational Risk Management' training resulted in obvious improvement in performance as indicated by the superior quality of risk mitigation plans submitted. Along with this increase in response value performance over the lesser trained pairs, were slightly faster response times.

As mentioned previously, the time taken to complete tasks was not of great concern, as in situations such as those presented during this study adequate time is normally allowed for completing assignments, always approximating 60 minutes.

Training did interact with decision aid indicating that level 2 trained teams were better able to make use of the decision aid in addition to their already superior performance. This gain in performance was associated with an increase in the time required to complete the task suggesting that although training improved the usefulness of the decision aid it did not make it's use more efficient.

That more highly trained individuals and groups should demonstrate superior performance is consistent with the literature. Prior task knowledge or expertise in a domain is shown to significantly effect the way in which information is processed (Alba & Hutchinson, 1987; Chi, Glaser, & Farr, 1988; Shanteau, 1988). Experts are capable of using greater knowledge and searching continently for limited sets of variables, due to their knowledge of the domain (Bouman, 1980; Elstein, Shulman, & Sprafka, 1978; Libby & Frederick, 1989). Since they search less, they are capable of reducing information processing (Ericsson & Chase, 1981), possibly explaining the slight advantage in time to complete the task for the level 2 trained participants in the present study. Experts have been shown to have a more active pattern of contingent search, where subsets

of variables are considered for each case and in different sequences (Bouman, 1980; E. Johnson, 1988; Bedard & Mock, 1989; Kleinmuntz, 1968; Elstein, Shulman, & Sprafka, 1978; Johnson, Hassebrock, Duran, & Moller, 1982). Though missing information degrades domain knowledge for all, it has been shown that experts and novices respond differently to missing information. Experts are more likely to notice information missing and to infer probable values for the items missing (Sanbonmatsu, Karkes, & Herr, 1992).

Unfortunately, even with presumed expertise in a domain, associated concerns for expertise arise. Despite increased knowledge, experts at times make poor predictions. Their knowledge is frequently biased, especially when derived from judgmental heuristics or improper use of heuristics when applying them (Goldstein & Hogarth, 1977). Experts weight cues inconsistently often due to context effects (Camerer, 1989), relying heavily on prior knowledge to encode, organize, and manipulate information (Cosmides & Tooby, 1994).

Repeated and routine operation, such as those performed during over-learned tasks, employ procedural memory which at times causes actions taken to become implicit to the decision maker (Ronis, Yates, & Kirsch, 1989). During 'category based' decision-making, such decision-makers quickly recognize alternatives as members of a category for which an action or judgment has previously been stored (Chase & Simon, 1973).

When reminiscences become unconscious, episodic memory provides a basis for intuitive decision-making (Logn, 1988). When the decision maker progresses to the point of no longer actively guiding the deliberation process by following defined procedure, 'associative deliberation' takes place where thoughts are influenced by whatever considerations come to mind during the moment (Busemeyer & Towsend, 1993). Such situations encourage the misguidance of experts.

Additionally, experts often use configural choice rules, where the impact of one variable depends on values of others (Kleinmuntz, 1985). They, at times, do this inaccurately. Such rules require only the simple categorization of cue values suggested by prior theory, however intruding factors such as the representativeness heuristic often cause errors (Klienmuntz, 1985). Though these rules may assist in establishing a causal narrative around a current theory, in a desire to attempt explaining the present from past experiences individuals may overweight cues thus force fit a general rule inappropriately (Brehmer, 1980; Meyer, 1987). Not only may configural rules be inaccurate due to over-generalization, these may also be incorrect due to their implicit theories having been derived incorrectly or not sensitive to small errors. Advanced training affords operators with greater resources with which to select options from, and experience in doing so carries out through situations of greater stress.

Decision Aids. Decision aids improved performance regardless of the level of training but the two-way interaction indicated that they had a greater performance benefit for level 2 trained teams. Participants allowed use of an aid (at level 2 training) gained a mean 'response value score of 14.724, which is a significant increase (53 percent) above similarly trained participants who recorded 8.817. Likewise, participants trained at level 1 and allowed use of an aid attained a score of 5.648, significantly (57 percent) above the 3.239 attained by similarly trained participants not equipped with the decision aid. Thus, when performance was measured in 'response value', results were found favoring those with higher levels of *training*.

Greater differences in time to complete tasks were revealed during comparison of groups allowed use of a decision aid versus those not allowed usage, as compared to the effects for training. At training level 1, groups using a decision aid took over 14 minutes (M= 14.195 min) longer to complete tasks than similarly trained groups not using an aid. Between the level 2 trained groups, those allowed a decision aid required 12 minutes longer to complete assignments than did those operating without an aid. Although such results were anticipated (Kahneman & Tversky, 1973; Prince, Chidester, Bowers, & Cannon-Bowers, 1992), the degree to which participants allowed the aid actually referred to this assist during testing was greater than had been expected. General observations made by

test administrators made it clear that participants provided an aid used it continuously throughout testing, resulting in longer times to complete tasks.

This phenomena may be viewed in either of two manners. If a decision aid reduces the effort associated with employing one particular procedure relative to others, the human will be inclined to employ the strategy made easier (Payne, 1992). This may or may not be beneficial, depending on whether the procedure accepted is the best possible. Similarly, if two procedures of equal effort are befitting, decision-makers are more likely to employ the one perceived providing the personally preferred solution (Payne, 1992). In the present study the aid served its' intended purpose by providing a timely and acceptable procedure to the decision-maker. As decision-makers frequently employ decision aids to maintain the lowest level of cognitive effort expenditure, when a particularly attractive procedure is presented via an aid this convention may be the one accepted rather than expending further effort considering competitors or alternatives. Either explanation may be inferred, as regular attempts at reduction of effort in decision-making is consistent with the literature on behavioral decision theory (Payne, *et al.*, 1993). The ultimate value of the aid rests in the quality of the aid itself, and seen in the form of either favorable or unfavorable results. Also, usage is dependent on time available.

Overall, considering training and decision aid usage in combination, the preferred situation was obviously observed when participants were more highly trained (level 2 training) and allowed use of a decision aid, especially when contrasted with the less trained performing without an aid. Though an increase in required time to complete task of over 10 minutes (M= 10.264 min) could be attributable to decision aid usage, performance improved over four and one-half fold (means of 3.239 min versus 14.724 min) when advanced training and decision aids were offered participants (though only double over what a level 2 trained team could do without the aid). Thus, the ideal environment would apparently be operators trained considerably, and provided a quality physical aid for additional and immediate assistance.

Although participants provided the *aid* consistently required greater time to complete tasks, this should be considered inconsequential given the fact that performance increased mainly as a function of *training* level, the higher trained participants regularly outperforming those less trained. The extra time required of groups given an *aid* for assistance only served to increase completion times by an average of less than three minutes (i.e., lesser trained participants averaging three minutes longer as a group to complete tasks as opposed to higher trained, when both were provided the *aid*).

The idea that aiding might benefit decision-making, even for the

assumed expert decision-maker, is consistent with previous research. It has long been known that humans are motivated to use as little effort as necessary to solve problems (Zipf, 1949). When given the opportunity, humans will select the most advantageous yet least costly method of arriving at what is felt the acceptable conclusion, at times rationalizing to the point of non-optimal satisficing. From Simon's (1955, 1956) early work on bounded rationality, one realizes the need that psychological theory respect human cognitive limitations. Additionally, Payne, et al. (1993) emphasize the multiplicity of people's decision strategies and their ability and willingness to adapt these to circumstances, though at times incorrectly.

Beach and Mitchell (1987) argued that too much importance is placed on the selection of an optimal member of a choice set, as opposed to the way humans actually screen individual alternatives for compatibility with personal values, goals, and plans, and the method in which ongoing plans are monitored. For example, Tversky (1969) suggested that the individual tendency to evaluate distinct stimuli in their entirety, as opposed to employing intra-dimensional comparison, depends on the manner in which the alternatives are displayed. Format presentations (decision aids) prompt humans to consider various outcomes separately versus aggregated which humans have a preference for, rather than considering aggregations of outcomes collectively and being forced to

perform extreme mental accounting (Linville & Fisher, 1991; Thaler, 1985).

Both the novice and expert decision-maker should benefit from whatever aid provided, if constructed and presented properly. Tversky (1969), in conducting his 'Additive Difference Model', offered two hypotheses concerning the processes of multidimensional choice: 1) people tend to compare alternatives on each dimension in turn, as opposed to evaluating each alternative in its entirety before considering overall evaluations, and; 2) naive people neglect dimensions for which the alternatives are "too close to call". By applying decision aiding in judgmental situations, restraint of the expert from a hasty scan of the alternatives can be fashioned, while supplemental information for consideration may be offered the novice. Additionally, option based procedures using examples such as aids have been found to elicit greater numbers of options (Keller & Ho, 1988), as witnessed in performance benefit during the current research for participants trained at all levels.

Thus, even for the situation involving the deemed expert, not only it is grounded in science, but it would also appear logical to offer cognitive supports (Woods & Roth, 1988) such as the display of possible choices (Edwards, 1987; White, 1990), situational cues (Shortliffe, 1976), diagnoses information and suggestions (Gordon, 1991), warnings of circumstance changes (Guerlain & Bullemer, 1996), and assists in generating possible

goals (Eberts *et al.*, 1984) when predicting future status (Schraagen, 1997). Such redundant informational or advisory support enhancements should naturally assist in providing guidance, whether in the form of performance support systems or skill training aids, serving to increase operator declarative and procedural knowledge (Wexley & Latham, 1991).

At this point one note should be made concerning the benefits for the combined application of advanced training and decision aiding. Interestingly enough, although both advanced training and the use of a decision aid were seen to improve performance in the current study, these did not do so in strict linear fashion. Though the impact of increased risk could be seen to take its toll on performance as expected, the type risk particularly appeared to have influence. This became apparent between conditions presenting risk due to fatigue and risk due to possible loss of life, suggesting that when and where either advanced training or decision aid usage might be employed to positively effect a situation may be dependant upon the nature of risk presented. The question appears a lucrative area for future research.

<u>Scenario Type (Risk factor)</u>. Overall, the three scenarios used in the present study clearly provide teams with varying levels of challenge, as indicated in the main effect for 'risk'. The effects for risk observed during the current study per scenario include interactions between independent variables that are noteworthy. Scenario #1, a somewhat routine flight

task, presented the least risk. Scenarios #2 and #3 presented greater risk, the former in the form of risk due to fatigue while the latter due to potential loss of life. Both advanced training and use of a decision aid produced improved performance in terms of 'response value' under all conditions. The performance decrease during the more adverse conditions had been expected. However, while performance was seen to decrease as a function of risk (varied per the three scenarios provided), this was not influenced equally by training level and decision aid usage.

The results shown in Figure 2 indicate that the advantage gained from training was maximized in scenario's #1 and #2, with little difference in performance for scenario #3. It is reasonable to assume that the nature of scenario #3 (possible loss of life) constitutes a difficult situation to assess, yet at the same time is one which is address early in the training process and thus not as likely to benefit from the advanced 'maintenance' training. Further, if level 1 trained teams recognize the increased risk apparent in scenario #3, it may also be that they under estimate the level of risk in non-combat missions. On an anecdotal level, this may be supported by the accident rate among military crews operating in non-combat roles.

With respect to the decision aiding, this too did not provide a uniform performance benefit across scenarios. Results further suggest that the benefit of aiding, like that of training, was primarily apparent in

scenarios #1 and #2. Again, this effect may be attributed to the nature of the training early on, which emphasizes combat risks over non-combat mission risks.

Homogeneity. Concerning group homogeneity, the resultant inter-correlation between the independent variable *homogen* (representing group homogeneity) and the independents *training* level and decision *aid* usage negated homogeneity from displaying improved or degraded group performance during this effort, in contrast to prediction. Thus, at first glance, one may assume group homogeneity not important during decision-making. However, given the parameters of this study, an alternative explanation offered is that this may be a result of the measure used to determine participant action-state orientation, particularly the "Action Control" assessment itself. Though previous research efforts provided validation for the influences of action- versus state-orientation on decision-making behavior (Kuhl & Beckmann, 1994; Stiensmeier & Schnier, 1988; Niederberger, Engemann, & Radtke, 1987), none considered influence as a function of task or environment.

In the current study, time limitations for completing tasks were not severely constrained nor manipulated. Most notably, and as observed by Payne (1998a), time pressure modifies the influences of action and state orientation since differing responses to time pressure may either: 1) accelerate information processing; 2) increase the filtration of

information; 3) result in a change in heuristic usage, or; 4) cause modification of the strategy employed by the decision-maker. Though keenly aware of task severity, participants felt they had adequate time to complete tasks, thus instantaneous responses were not considered necessary.

Certainly situations such as the limitation of allowable time should necessitate differences in the amount of action control required. For example, the human response to time pressure of accelerating information processing would not demand a significant amount of action control (Baron, Kerr, & Miller, 1992; Lin, & Ross, 1990). Thus, this would not be reflected in individual differences measured on the action-state orientation construct, as an action attribute specifically reflects the ability to make decisions timely in contrast to state attribute. In fact, and to the contrary, a group collective state orientation may at times be beneficial, in that individual group members remain more deliberate, diligent, and contemplate thought longer which should increase quality of performance during tasks requiring careful decision-making if given adequate time to do so. Neither stringent restriction nor inexhaustible or an overabundance of time was afforded during this study, thus the scale used to determine influences of individual construct performed in a manner not anticipated. However, as increased performance associated with longer task completion time was observed in this study both attributable to

decision aid usage, the normally found speed versus accuracy trade-off is once again apparent.

Contingency Theory of Decision-Making. As performance (recordings of 'response value' and 'time' to complete tasks) varied per level of training and with or without a decision aid, participants provided the decision aid would have to employ a contingent decision-making strategy, returning to previous stages in the decision-making process to re-evaluate prior actions, when prompted to do so by the aid. Such recorded changes would have occurred as a result of either searching memory for association with prior experiences (influence of the higher level training), or to make comparisons between proposals and the decision aid provided. In doing so, reversion to previously encountered stages of the decision-making process would apparently be eminent. Evidence of decision aid usage during the current study could be seen in the longer (though small) times to complete tasks recorded consistently between similarly trained groups, with improved performance constantly observed among groups provided the aid the possible consequence.

Invariably effecting option selection are experience in a decision domain, and the accessibility of strategies. Problem characteristics such as lack of information displayed should further influence cognitive effort, because the number and quality of options generated is affected by the effort needed to retrieve these from memory (Goschke & Kuhl, 1993).

Thus, solutions to identified problems during this effort were apparently generated through active search, most likely with use of preplanned solutions for problems similar (Shaklee & Fischhoff, 1982b), culminating in elimination of unattractive options by screening for negative aspects to reach the most favorable solution once prior selections were reconsidered. This is a contingent schema, and appears in accordance with Elion's (1969) contingent decision strategy process stages five through eight, abbreviated respectively; 1) generation of alternatives for problem solving; 2) prediction of consequences for each alternative; 3) option evaluation by the specification of criteria for selecting among alternatives, and; 4) selection of option and on to implementation, the final decision resolution.

In this study, participants were placed into varying conditions of risk certainly causing instances of uncertainty. Their expectations (personal beliefs in how likely options might lead to specific outcomes) were influenced by values assigned to aspects of each proposed plan for contingency. Participants in the current effort must have experienced unsure feelings of future consequences for accepted choices (Sniezek and Buckley, 1995), as each choice inherently implied both positive and negative options. Thus, outcomes might be different had one or more clue interpretation been different.

Given the effect for individual perception coupled with situation uncertainty, such influences at times override beliefs resulting in the over-weighting of short-term benefits. Over-weighting also causes individuals to question considerations prior to making the final decision (Quattrone & Jones, 1980). In such cases, reversion to previously encountered stages of the decision-making process for reference is inevitable to reaffirm previously accepted judgments, and to consider contingents.

Implications

The pattern of results uncovered in the current research indicates the extent to which information concerning advanced training and use of decision aids may be useful. The type and degree of training afforded influences human performance, as will properly fabricated and displayed physical assists in the form of decision aids. Thus, in such situations, human performance is capable of being altered.

<u>Consideration For Level Of Expertise</u>. Properly applying the skill-rule-knowledge cognitive control model of decision-maker proposed by Rasmussen (1986), the practitioner concerned with human performance may find advantages to intervene at all three levels (novice, journeyman, and expert respective to the model), offering recommendations in an attempt to improve performance while reducing error. Skill-based control

is characterized by automated processes, and associated with perceptual memory. Rule-based control is distinguish by feed-forward goal oriented behavior based on rules developed after experience or training. This type of control seeks to specify task and environmental cues amiable to immediate association, and to later match these with stored rules to suggest the most appropriate action. The highest conceptual representation of a situation is at the knowledge-based level, which serves a global control function concerned with appropriate goal setting processes (Rasmussen, 1987).

During episodes of decision-making, control of reasoning may be transferred among all levels of expertise per the availability of information and as context-dependent situations necessitate (in other words, the problem state determines the level of situation control necessary). At the higher level of processing, after an individual has identified and accepted an appropriate rule, automated skill-based control again becomes activated as at this point this is all that is necessary, resulting in a change in the task environment. Control later returns to the knowledge-base level for monitoring progress of this activated procedure towards the intended goal.

In the current study, scenario #1 (presenting the least risk condition) was found significantly different than scenarios #2 and #3 (the higher risk conditions). However, comparable levels of performance

could be seen among all three scenarios, as advanced training and decision aid usage increased performance similarly. The influences of advanced training and decision aid usage were improved performance, regardless of test participant expertise or condition. Obviously, such advantages would be most appreciated by all operators during higher risk conditions.

The fact that training increased 'response value' significantly but had little effect on time is consistent with Rasmussen's theory of skill- rule- knowledge-based model, in that at each successive level there is a gain in decision quality though not an associated gain in time required. Hence, someone using a knowledge-based decision-making approach world proceed at the same speed as one who used skill-based approach, however the quality of decision differs. Likewise, it would also be rational that the benefit of a decision aid would increase time because it does not move the decision-making from rule-based to knowledge –based. Instead, the decision aid increases the number of rules that must be considered. Again, the level of effort and requirements for operation depend highly on the task and problem domain.

Research suggests fundamental differences between the ways in which experts and novices solve problems, specifically in how knowledge is represented and the information processed. Experts represent problems at a higher level of abstraction than novices, because previous experience with diverse problems enables them to develop heuristics which reduce

the search space of the problem (Newell & Simon, 1972). Novices focus on surface features of a problem, using a strategy of incrementally decomposing the task to solve sub-problem aspects. Applying this information-processing perspective, a theoretical background is provided which may be appropriate for the way in which individuals constructs mental models of a task. The type of information required for learning coupled with situational circumstances determines the relative importance of skill-, rule-, or knowledge-based cognitive control. For example, when presented a novel situation, expert behavior appears similar to the novice. In such situations, an expert exhausts his or her collection of rules and knowledge first to solve the problem, then focuses on surface features of the problem as would a novice (Reason, 1987).

Considerations For Training. The application of advanced training would appear appropriate in improving group decision-making performance, as shown in the current study, given that this is conducted fittingly and as required. Before group member can begin to focus on developing effective teamwork skills, they must first be trained to reach some threshold level of competence in individual knowledge (Guerette, Miller, Glickman, Morgan, & Salas, 1987). However, though individual skills are important components of Team performance, researchers agree that training must be designed to develop both individual and team skills and made to maintain these (Davis, Gaddy, & Turney, 1985; Dyer, 1984;

Hall & Rizzo, 1975). This includes supporting case-based reasoning (Kolodner, 1991) and repetition to support retention (Driskell, Willis, & Cooper, 1992). Other suggestions are to capitalize on the natural tendencies for humans to seek causal relations between variables (Einhorn & Hogarth, 1981; Medin, Altom, Edelson, & Freko, 1982; Phelps & Shanteau, 1978), to utilize cross-training for increasing team shared knowledge (Cannon-Bowers, Tannenbaum, Salas & Conveerse, 1991; Travillian, Volpe, Cannon-Bowers, & Salas, 1993), and to train team members with individuals they will be operating among (Orasanu & Salas, 1993; Ford & Noe, 1987).

Considerations For Decision Aiding. Decision aiding has gained favor, especially in light of the advances made in computing capacity and speed. The ability to flexibly deal with a lack of structure is the primary reason for employing humans as decision-makers, otherwise an automated process would be used. However, situations in which alternatives are unclear, time is constrained, with vague decision attributes provided do not allow for extended analysis such as would be amenable to a machine, thus humans are required as operators. Unfortunately, shortcomings surface when humans try to determine how to integrate all information relevant to a decision (Dawes, 1982), and find themselves quickly becoming less-than-expert decision-makers. In such situations, automated assistance can be essential.

A second obstacle to improving decision-making concerns the tendency for personal expectations concerning how decisions should be made, as cultural expectations lead to over trust in intuition above judgments offered from other sources. Overconfidence is a twofold problem: 1) it has been shown to negatively effect particular decisions, and; 2) it inflates the humans view of his or her decision-making capabilities. Regrettably, simply informing decision-makers about possible biases in decision-making (including overconfidence) results in little improvement (Arkes, 1986; Fischhoff, 1982b). Though studies have been conducted showing overwhelming support for the use of non-human mechanisms in judgment and choice (Dawes, 1982; Dawes & Corrigan, 1974), contrary to human personal beliefs it may be more rational to use decision aids rather than to rely exclusively on human impressions of a situation (Kleinmuntz, 1990).

For decision aiding to be effective, experts and novices must be considered independently. The novice requires greater amounts of operational knowledge, such as being shown when something is not normal, and then provided procedural methods for rectifying the error. Using intuition, the expert will recognize situations not presented in operational procedures, and begin a problem solving approach (Boy, 1988). Moray (1988) suggests that decision aids for experts should be developed as a "lattice", providing paths otherwise inaccessible to the operator. The

rationale for this is that after hours of operation (thus, reaching expertise), experts no longer explore functions inductively. They have already complied a repertoire of rules for what they believe to be all situations possible, and will then work only at nodes in the lattice for gaining a complete picture (a mental model) of the situation.

One method of assist is to simply make the decision-maker aware of the nature of limitations and biases of which he or she may be unconscious of, by forcing the consideration of alternative hypotheses though give warning to the detriments of cognitive tunnel vision. Researchers have had favorable results in doing this. Koriat, Lichenstein, and Fischoff (1982b) discovered that forcing forecasters to entertain reasons for why their forecasts might not be correct reduced biases toward overconfidence in accuracy. Hunt and Rouse (1981) were able to succeed in training operators to extract diagnostic information in the absence of cues using a similar method. Lopes (1982) achieved success, training subjects to avoid anchoring biases when processing multiple information. She called subjects' attention to their tendency to anchor on initial stimuli, which may not have been adequately informative, and instead anchor on more enlightening sources. When this was done, biases were reduced.

Concluding Remarks

The intention of those seeking to assist decision-makers should be the design of training programs and systems for aiding which overcome human limitations in algorithmic reasoning, and provide better conditions for heuristics rationale. Training and decision aiding and should be targeted at strengthening the decision-makers preferred approach to a problem, rather than replacing it altogether. By offering enhanced training while providing decision aiding to adjust for recognized human deficiencies, poor processes and traits found within groups may be corrected or otherwise redirected to strategies beneficial to the intended purpose. One must consider that the human will utilize any information made available, and may be directed towards such information in several manners.

Though previous research performed using groups created in-laboratory has produced valuable theoretical insight into the group decision-making process, the question of whether these perspectives generalize beyond the laboratory is not often apparent (Michaelsen, Watson, & Black, 1898; Michaelsen, Watson, Schwartzkopf, & Black, 1992; Tindale & Larson, 1992). Seeger (1983), and again Tetlock (1985), note that academic literature on group decision-making is usually based on data drawn from groups created artificially and in a laboratory setting, as they are being asked to perform arbitrary tasks. Given these restraints, it is only

logical to ask whether conclusions reached are similar to that which might be expected of real teams in actual organizational contexts (Hackman, 1990; Janis, 1989).

For the current research, a number of efforts were exerted to maximize the realism of the experimental situation, including the presentation of authentic flight scenarios performed under genuine operating conditions, and with use of actual military pilots (of the Cobra attack helicopter) conducting genuine tasks. Additionally, this simulation was quite successful in absorbing test participants in assignments and holding their interest, which was exhibited in participant exit interview comments. Thus, at a minimum, it can be said that greater than a modicum of experimental realism was achieved, and that results should be generalizable affording insight into the nature of group decision-making in a technological context.

Despite any limitations in the current effort such as providing a small amount of scenarios with which to make judgments from and the fact that participants knew they were taking part in an experiment only and would not actually be required to fly missions commented on, the current research confers implications for both theory and measurement. From a theoretical standpoint, a conceptual framework is offered to begin addressing the critical need to systematically investigate theories of influences on decision-maker attributes. In addition to advancing the

literature conceptually, this study also makes important contributions from a measurement standpoint. The pattern of results uncovered in the current effort allow the development of guidelines, supporting the notion that instances exist in which the human factors professional might intercede to improve human performance and reduce error.

Group decision-making is said to be efficient only if it consumes a reasonable amount of resources. Future efforts should concentrate on examining methods for determining the information decision-makers especially require, and progress to deducing preferred methods for providing this.

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Appendix A: Kuhl's "Action Control Scale"

Action Control Scale (ACS-90)

{English version of the German HAKEMP-90}

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The action control scale consists of three sub-scales: 1) action orientation subsequent to failure vs. preoccupation (AOF); 2) prospective and decision-related action orientation vs. hesitation (AOD), and; 3) action orientation during (successful) performance of activities (intrinsic orientation) vs. volatility (AOP).

Each scale consists of 12 items which describe a particular situation. Each item has two alternative answers (A or B), one of which is indicative of action orientation and the other of state orientation.

For scoring the test values, using the action-orientated answers is recommended. The sum of the action-orientated answers for each scale is between 0 and 12.

The items are numbered from 1-36. Which items belong to which scale, and which choice alternative is indicative of action orientation, can be found in the following key: a) *Failure-related action orientation vs. preoccupation (AOF):* 1B, 4B, 7A, 10A, 13B, 16B, 19A, 22B, 25B, 28B, 31B, 34A; b) *Decision-related action orientation vs. hesitation (AOD):* 2B, 5B, 8B, 11A, 14B, 17B, 20B, 23A, 26A, 29B, 32A, 35A, and; c) *Performance-related action*

orientation vs. volatility (AOP): 3B, 6B, 9A, 12B, 15A, 18B, 21A, 24B, 27A, 30B, 33B, 36A.

When scoring the questionnaire, the three scales should be scored separately, since each scale deals with a different behavioral aspect of action orientation. If a case arises where giving the entire 36 item questionnaire is not possible, then two of the three scales should be given, rather than only part of the three scales. Since the AOP scale can be affected by several variables other than action/state orientation, this scale can be left out if this particular behavioral aspect has no special importance in the planned study. The scales AOF and AOD should always be administered together.

. . . .

Choose the one of the possible answers (A or B) that is most like you and give an answer for every question on the supplied answer sheet. Please don't make any marks on this questionnaire.

1) When I have lost something that is very valuable to me and I can't find it anywhere:

A. I have a hard time concentrating on something else.

B. Put it out of my mind after a little while.

2) When I know I must finish something soon:

A. I have to push myself to get started.

B. I find it easy to get it done and over with.

3) When I have learned a new and interesting game:

A. I quickly get tired of it and do something else.

B. I can really get into it for a long time.

4) If I've worked for weeks on one project and then everything goes completely wrong with the project:

A. It takes me a long time to adjust myself to it.

B. It bothers me for a while, but then I don't think about it anymore.

5) When I don't have anything in particular to do and I am getting bored:

A. I have trouble getting up enough energy to do anything at all.

B. I quickly find something to do.

6) When I'm working on something that's important to me:

A. I still like to do other things in between working on it.

B. I get into it so much that I can work on it for a long time.

7) When I'm in a competition and have lost every time:

A. I can soon put losing out of my mind.

B. The thought that I lost keeps running through my mind.

8) When I am getting ready to tackle a difficult problem:

A. It feels like I am facing a big mountain that I don't think I can climb.

B. I look for a way that the problem can be approached in a suitable manner.

9) When I'm watching a really good movie:

A. I get so involved in the film that I don't even think of doing anything else.

B. I often want to get something else to do while I'm watching the movie.

10) If I had just bought a new piece of equipment (for example, a tape deck) and it accidentally fell on the floor and was damaged beyond repair:

A. I would manage to get over it quickly.

B. It would take me a long time to get over it.

11) When I have to solve a difficult problem:

A. I usually don't have a problem getting started on it.

B. I have trouble sorting out things in my head so that I can get down to working on the problem.

12) When I have been busy for a long time doing something interesting (for example, reading a book or working on a project):

A. I sometimes think about whether what I'm doing is really worthwhile.

B. I usually get so involved in what I'm doing that I never think to ask about whether it's worthwhile.

13) If I have to talk to someone about something important and, repeatedly, can't find her/him at home:

A. I can't stop thinking about, it, even while I'm doing something else.

B. I easily forget about it until I can see the person again.

14) When I have to make up my mind about what I am going to do when I get some unexpected free time:

A. It takes me a long time to decide what I should do during this free time.

B. I can usually decide on something to do without having to think it over very much.

15) When I read an article in the newspaper that interests me:

A. I usually remain so interested in the article that I read the entire article.

B. I still often skip to another article before I've finished the first one.

16) When I've brought a lot of stuff at a store and realize when I get home that I paid too much – but I can't get my money back:

A. I can't concentrate on anything else.

B. I easily forget about it.

17) When I have work to do at home:

A. It is often hard for me to get the work done.

B. I usually get it done right away.

18) When I'm on vacation and I'm having a good time:

A. After a while, I really feel like doing something completely different.

B. I don't even think about doing anything else until the end of my vacation.

19) When I am told that my work has been completely unsatisfactory:

A. I don't let it bother me for too long.

B. I feel paralyzed.

20) When I have a lot of important things to do and they must all be done soon:

A. I often don't know where to begin.

B. I find it easy to make a plan and stick with it.

21) When one of my co-workers brings up an interesting topic for discussion:

A. It can easily develop into a long conversation.

B. I soon lose interest and want to go do something else.

22) If I'm stuck in traffic and miss an important appointment:

A. At first, it's difficult for me to start doing anything else at all.

B. I quickly forget about it and do something else.

23) When there are two things that I really want to do, but I can't do both of them:

A. I quickly begin one thing and forget about the other thing I couldn't do.

B. It's not easy for me to put the thing that I couldn't do out of my mind.

24) When I am busy working on an interesting project:

A. I need to take frequent breaks and work on other projects.

B. I can keep working on the same project for a long time.

25) When something is very important to me, but I can't seem to get it right:

A. I gradually lose heart.

B. I just forget about it and go do something else.

26) When I have to take care o f something important but which is also unpleasant:

A. I do it and get it over with.

B. It can take a while before I can bring myself to do it.

27) When I am having an interesting conversation with someone at a party:

A. I can talk to him or her the entire evening.

B. I prefer to go do something else after a while.

28) When something really gets me down:

A. I have trouble doing anything at all.

B. I find it easy to distract myself by doing other things.

29) When I am facing a big project that has to be done:

A. I often spend too long thinking about where I should begin.

B. I don't have any problems getting started.

30) When it turns out that I am much better at a game than the other players:

A. I usually feel like doing something else.

B. I really like to keep playing.

31) When several things go wrong on the same day:

A. I usually don't know how to deal with it.

B. I just keep on going as though nothing happened.

32) When I have a boring assignment:

A. I usually don't have any problem getting through it.

B. I sometimes just can't get moving on it.

33) When I read something I find interesting:

A. I sometimes still want to put the article down and do something else.

B. I will sit and read the article for a long time.

34) When I have put all my effort into doing a really good job on something and the whole thing doesn't work out:

A. I don't have too much difficulty starting something else.

B. I have trouble doing anything else at all.

35) When I have an obligation to do something that is boring and uninteresting:

A. I do it and get it over with.

B. It usually takes a while before I get around to doing it.

36) When I am trying to learn something new that I want to learn:

A. I'll keep at it for a long time.

B. I often feel like I need to take a break and go do something else for a while.

AO/SO-Anxiety Scales

Action and state orientation, anxiety-specific items

- Extensions to the Action Control Questionnaire -

Johanna Hartung and Thomas Schulte-Bahrenberg

Like Kulh's ACS, the AO/SO-Anxiety Scales consist of three subscales: a performance-related scale, a failure-related scale, and a planning-related scale. For each scale the action-oriented answers are scored: Performance (Items 1b, 2a, 3a, 4b, 5b, 6b, 7a); Failure (Items 8b, 9a, 10a, 11b, 12b, 13a, 14b); Planning (Items 15a, 16a, 17b, 18b, 19a, 20b, 21a, 22b).

. . . .

Choose the one of the possible answers (A or B) that is most like you and give an answer for every question on the supplied answer sheet. Please don't make any marks on this questionnaire.

1) When I've managed to drive or go somewhere:

   A. I am very scared when thinking of having to drive or go back.

   B. I feel proud of myself.

2) When I do not feel scared in a situation and this is against my expectations:

   A. I fully concentrate on what I'm just doing.

B. I carefully observe myself whether there might be any signs of fear after all.

3) When I have overcome my fear successfully:

A. I enjoy this success for a long time.

B. I soon start thinking of the next anxiety situation.

4) When I feel at ease in a situation:

A. I often think what a pity it is that my fear spoils so many good experiences.

B. I can fully enjoy the moment.

5) When I'm in a situation in which I had already suffered a fear attack some time:

A. I automatically think of it and feel alarmed.

B. I manage to concentrate on the current situation.

6) When I've managed to reach a small aim:

A. I often wonder whether I'll ever be free of anxiety.

B. I feel rather happy.

7) When I feel anxious in a situation:

A. I try to concentrate on what I'm doing.

B. I work myself up into my fears.

8) When my anxiety problem keeps me from reaching a certain goal:

A. I keep thinking of this unaccomplished goal.

B. I soon switch over to other activities.

9) When I've had a fear attack:

A. I do something that makes me feel strong again.

B. I keep mulling on the question whether my behavior is still normal.

10) When I did not manage to hide my fear from strangers:

A. I soon think about something else.

B. I feel embarrassed for a long moment.

11) When I find myself being afraid of something that doesn't seem to affect other people:

A. I keep wondering why I'm different from others.

B. I nevertheless try to find a way to cope with the demands.

12) When I've tried for once to ignore my anxiety, and failed:

A. I think: "You will never make it!".

B. I wonder how to do better the next time.

13) If my companion cancels an appointment at short notice:

A. I often do on my own the things I had planned.

B. I feel left alone.

14) In situations when I couldn't prevent a fear attack:

A. I feel myself completely surrendered to my fear.

B. I think of trying something new the next time in order to cope with my anxiety.

15) When I'm in for something unpleasant:

A. I try to get through with it as quickly as possible.

B. I dream of how nice it would be to be free of fear at last.

16) When I have planned to do something without other peoples' help:

A. I don't let myself be talked out of it easily.

B. Then often something happens that discourages me again.

17) When I have two ways to gain an end, but both cost quite an effort:

A. I am discouraged and don't know what to do.

B. I immediately decide for the lesser evil.

18) When I face something difficult:

A. I often worry about what trouble might happen.

B. I only consider the most important things in my planning.

19) When I'm confronted with a demand that fills me with fear:

A. I get through with the matter as quickly as possible.

B. I put the matter off as long as I can.

20) When I would like to undertake something:

A. I keep wondering whether or not I should set forward without company.

B. I set out soon.

21) When I have to set myself a difficult task:

A. I mostly go to work with confidence.

B. I worry about all sorts of difficulties.

22) When an unpleasant situation impends:

A. I often think, how terrible it would be if I got scared in the situation.

B. I think about how to master it.

....

Action versus state orientation was observed for the prediction of performance as a continuously distributed subject level variable. This was accomplished by using group averages, where the squared within-group deviation was considered a measure of group homogeneity (combining subject scores in each group, averaging these, determining the deviation between these, and then applying the squared deviation). Rationale for this methodology is presented in the succeeding paragraphs.

When group members are found 'action' orientated (action-action) thus homogenous: 1) if favorable performance scores are recorded, this would suggest that future groups should be formed homogenous based on a personality construct assessment. However, if poor scores are recorded, this would suggest that either group homogeneity (based on the assessment of a personality construct) does not matter or possibly that to do this may be detrimental, and; 2) if favorable scores are recorded, this would suggest that by insisting on homogenous group membership performance should be superior (based on assessments of members found highly action orientated), unless a similar finding was uncovered for homogeneous groups found highly state oriented.

When group members are 'state' orientated (state-state) thus homogenous on this construct: 1) if favorable scores are recorded this again would suggest that groups should be formed homogenous, based on this personality construct. However, if poor scores are recorded, this

would suggest either that group homogeneity does not matter, or that creating groups as such a way may be detrimental, and; 2) if favorable scores are recorded, this would again suggest that homogenous group membership (based on "Action Control Scale" assessment, though using the personality construct 'state' orientation) may benefit performance.

When one group member is assessed 'action' oriented while the other found 'state' oriented (action-state) thus *not* homogenous, if favorable performance scores are recorded this would suggest group homogeneity does not matter. This may also suggest that it does not matter whether a person is 'action' or 'state' oriented.

The items are numbered from 1 to 36. Which items belong to which scale, and which choice alternative is indicative of action orientation is determined by the following key: 1) Failure-related action orientation versus preoccupation (AOF): 1B, 4B, 7A, 10A, 13B, 16B, 19A, 22B, 25B, 28B, 31B, and 34A; 2) Decision-related action orientation versus hesitation (AOD): 2B, 5B, 8B, 11A, 14B, 17B, 20B, 23A, 26A, 29B, 32A, and 35A; 3) Performance-related action orientation versus volatility (AOP): 3B, 6B, 9A, 12B, 15A, 18B, 21A, 24B, 27A, 30B, 33B, and 36A. When scoring the questionnaire, the three scales should be scored separately, since each scale deals with a different behavioral aspect of action orientation, and later it is expected that these be combined. If a case arises where administering the entire 36 item questionnaire is not possible, then two of

the three scales should be given rather than only a part of the three scales. Since the AOP scale can be affected by several variables other than action-state orientation, this sub-scale can be left out if this particular behavioral aspect has no special importance in a planned study. However, the scales AOF and AOD should always be administered together. In the current effort, all categories were scored and utilized.

[In a recent study (n=92 phobic patients) the following estimates of internal consistency (Cronbach's alpha) have been obtained: Performance scale .75; failure scale .83; decision scale .86. The combined scale "action orientation in anxiety-relevant situations" obtained an internal consistency of .92.]

Appendix B: Test Participant Demographic Questionnaire

Questionnaire

Age: ______________ Gender: (male or female): __________________

Rank: ______________________ Date of Rank: ___________________

Current Flight Status (for example, **PI** - Pilot or Co-Pilot, **PC** - Pilot in-Command, **IP** - Instructor Pilot, **UT** - Unit Trainer, **SP** - Supervisory Pilot, other):

____

Time (approximate hours) in above category: _________________________

Flight Hours in Current Aircraft: ____________________________________

Combat Experience: 'Yes' ___ 'No'___ If 'Yes', which campaign(s) _______

____

Date (approximate) of last "Risk Management" Training: _________________

Years In Service: ___________ Years of Military Aviation: ____________

Any Comments you care to make: __________________________________

____

{ "Thank You" for your participation. }

NOTE: Within the U.S. Army, the intent for flight officers is to progress through experience. Thus, once rated as flight qualified, each pilot is considered in the status of "Pilot" (PL). "Pilot" status personnel, during their tenure while completing curriculum within the "Air Crew Coordination" course, receive "Operational Risk Management" 'Awareness' training only at this level. As a pilot progresses, he or she receives the status of "Pilot-in-Command" (PC). At this level, the PC is returned to training for "Operational Risk Management" 'Maintenance' training. After this, successful pilots go on to reach levels of "Unit Trainer" (UT), "Instructor Pilot" (IP), and finally "Supervisory Pilot" (SP) and "Experimental Pilot" (EP).

At the higher levels, pilots receive a series of refresher "Operational Risk Management" 'Maintenance' course sessions. Approximately one-half of the participants volunteering for this effort (n = 26) were classified "Pilot", while the remainder (n = 22) had reached the level of "Pilot-in-Command". This was the method with which test participants were divided along the two training level categories (level #1 -- 'Awareness', or level #2 -- 'Maintenance).

Per prior determination of level of training, participants were divided in half as those having had only the lower level of "Operational Risk Management" training (level #1, 'awareness') and those who had received further ongoing training (level #2, skill 'maintenance' training).

These two groups were again subdivided to allow half of each in conditions where they would receive a training aid (the 'check list'), with the remaining half presented conditions in which they would not receive an aid. The determination of action control level, assessed by administration of the "Action Control Scale", became a continuously distributed subject level variable, thus participants were not assigned to a particular condition.

Appendix C: Risk Assessment Response Sheet

Final RISK ASSESSMENT

with 'Contingency' Suggestion sheet

('Risk Mitigation Controls')

RISK ASSESSMENT

- ☐ **LOW**
- ☐ **GREATER THAN LOW**
- ☐ **MODERATE**
- ☐ **GREATER THAN MODERATE**
- ☐ **HIGH**
- ☐ **EXTREMELY HIGH**

... please STOP at this point, and enter 'Risk Assessment' TIME:

TIME: → ______

- -

Any comments you care to make: ______________________________

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- 'CONTINGENCY' for risk mitigation worksheet -

... when finished completing 'Contingency' work-sheet, please enter:

TIME: → [ ]

To avoid or alleviate a possible mishap concerning: ____________________

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I would recommend the following: ________________________________

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To avoid or alleviate a possible mishap concerning: ________________

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I would recommend the following: ______________________________

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To avoid or alleviate a possible mishap concerning: ________________

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I would recommend the following: ______________________________

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To avoid or alleviate a possible mishap concerning: ____________________

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I would recommend the following: ____________________________________

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To avoid or alleviate a possible mishap concerning: ____________________

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I would recommend the following: ____________________________________

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To avoid or alleviate a possible mishap concerning: ________________

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I would recommend the following: ______________________________

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To avoid or alleviate a possible mishap concerning: ________________

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I would recommend the following: ______________________________

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Subjects were provided with test scenarios presenting one of three type missions of expected average to adverse conditions. As a group, they were requested to return a decision concerning how the flight should proceed specifically via the submission of an implementation plan mitigating risk.

An example of the thought-process that went into the construction of a given matrix for 'Density Altitude Risk Matrix' follows: Density altitude is pressure altitude corrected for temperature. For a given elevation, the higher the temperature, the higher the density altitude. Higher density altitudes adversely affect aircraft performances and especially helicopter performance during critical flight phases, such as 'landing'. Therefore, as temperature goes up or the elevation increases, the corresponding "risk value" assigned that cell goes up. Once above 5000 feet elevation and with a temperature greater than 30 degrees Celsius, the risk for a becomes "extremely high". Therefore, for this example, the risk value is in the highest category.

Appendix D: Pre-Flight "Checklist"

'CHECK-LIST' (Rotary Wing Assessment Value Worksheet)

Five Step Risk Managment Process

1. Identify Hazards and Associated Risks.
2. Assess the Risks (what is the worst thing that can happen?).
3. Identify Controls to Reduce the Risks.
4. Implement the Control Measures.
5. Supervise the Operation and Assess Effectiveness of Control Measures.

Basic Rules of Risk Management

1. Accept No Unnecessary Risk.
2. Make Risk Decisions at the Appropriate Command Level.
3. Manage Risk in the Concept and Planning Stage.
4. Accept Risk Only When Benefits Outweigh the Costs.

(1) Command Relationship	RISK
Unit Briefer	L
Attached/OPCON	M

(2) Mission Planning	RISK PLANNING TIME		
MISSION STATEMENT	> 12 Hours Optimal	2 - 12 Hours Adequate	< 2 Hours Minimal
Specific	L	L	M
Implied	L	M	H
Vague	M	M	H

(3) MSN Complexity (circle all that apply)	RISK			
Task/Mission	DAY	NIGHT	NVG	IMC/SVFR
Admin/Support	L	H	M	M
ATM Tng / Eval / APART	L	M	M	M
MEDEVAC / SAR	M	EH	H	H
Multi-Ship OPNS	L	H	M	n/a
External Load	M	H	H	n/a
Aerial Gunnery	M	H	H	n/a

(4) Additional Factors	RISK		
Over-Water OPNS (any non-dunker qualifieds)	L	M	H
Sand / Snow / Dust Conditions	L	M	H
Mountain Terrain OPNS	L	M	H
Flight in Moderate Rain or Turbulence	L	M	H
Unmodified SPUR Gear	L	M	H
EMERG Procedure Training (Reduced Throttle)	L	M	H
Extreme Temperature (> 34 deg C or < -4 deg C)	L	M	H

(5) Weather Flight Condition	RISK > 1000 / 3	> 700 / 2	> 500 / 1
Day / VMC	L	H	EH
NVG / VMC	L	H	EH
Night / VMC	L	EH	EH
IFR / IMC	L	M	H

(6) Night Illumination % (Moon NOT Obscured)	RISK UNAIDED	NVG
23 - 100 % Illumination	L	L
< 23 % Illumination	L	M

(7) PC Experience Level Total Time in AO (Completed by PC)	RISK TOTAL TIME IN A CATEGORY > 1500	500 - 1500	< 1500
< 50	L	M	H
50 - 100	L	L	M
> 100	L	L	M
(Reduce Risk Level to LOW if the PC is a UT, IP, or IE)			

(8) PI Experience Level Total Time in AO (Completed by PI)	RISK TOTAL TIME IN A CATEGORY > 1500	500 - 1500	< 1500
< 50	L	M	M
50 - 100	L	L	M
> 100	L	L	L

(9) CE Experience Level Total Time in Aircraft (completed by CE)	RISK TOTAL TIME > 200	50 - 200	< 50
< 25	L	M	H
25 - 50	L	L	M
> 50	L	L	n/a
(Reduce Risk level to LOW for two CE on acft. or if CE is supervised by an FI)			

(10) Fighter Management Quality of Rest *(fill in for each crewmember)*	RISK HOURS OF REST			
Garrison	> 10	8 - 10	6 - 8	< 6
Field	L	M	M	M

1. If crewmemer is flying at night and has performed over 12 hours of duty prior to the beginning of mission, the reulting mission risk factor = MEDIUM.
2. Following applies to military duty days or combinations of civilian/military:
   a. Mission is conducted during 1st or 2nd third of day = LOW.
   b. Mission is conducted during last third of duty day = MEDIUM.

(11) PC NVG Experience (completed by PC)	RISK > 200	50 - 200	< 50
Within 15 Days	L	L	M
Within 45 Days	L	M	M
Within 90 Days	L	M	H

(12) PI NVG EXPERIENCE LAST NVG FLT *(completed by PC)*	RISK TOTAL NVG TIME > 100	50 - 100	< 50
Within 15 Days	L	L	M
Within 45 Days	L	L	M
Not Current	L	M	H

(13) CE NVG Experience LAST NVG FLT *(completed by PI)*	RISK TOTAL NVG TIME > 50	25 - 50	< 25
Within 15 Days	L	M	M
Within 45 Days	L	L	M
Not Current	L	M	H
(Reduce Risk level to LOW for two CE on acft. or if CE is supervised by an FI)			

(14) Recency of Experience TIME SINCE LAST PERFORMED *(completed for each crewmember)*	RISK PC	PI	CE
< 12 Months	L	L	L
> 12 Months	M	M	L
Never	H	M	M

Appendix E: Flight Scenarios #1, #2, and #3

Scenario #1

OPERATIONS ORDER 104TH MED. CO. STX 2 (TACTICAL Scenario)

REFERENCES: WASHINGTON Sectional Aeronautical Chart, 1:500,000, Current DOD Approach Charts.

EXPECTED TIME OF DEPARTURE: 1030
EXPECTED TIME OF RETURN: 2030
TIME ZONE USED THROUGHOUT ORDER: Local

TASK ORGANIZATION:
29th Aviation Brigade, Co C. 2-224th Aviation

1. SITUATION

a. Enemy Forces: Potentially hostile forces, elements of Botswania Militia.

b. Friendly Forces: 1st Inf. Bde., 29th LID, 2,nd Inf. Bde, 29th LID, 3rd Inf. Bde., 29 LID, DIVARTY

c. Attachments/Detachments: Unknown

2. MISSION: Host nation support. Division Commander wants to review troop encampments from the air. Rendezvous with U.S. UH-1 carrying Division Commander at AA Weide (Weide AFF) and fly along specified route. Return with Passenger to A.O. Weide.

3. EXECUTION: The intent is that elements of C Co 2-224 Avn transport personnel safely to it's destination.

a. Concept of Operation: Depart A.A. Weide at IP 40-East to Norrisville Substation (Approx. 32 nm. BAL 015 radial) SW to Fowlesburg. Travel SSW to Sykesville Sanitarium then along designated route; to AA Weide. Call all required check points on assigned frequencies. Maintain altitude restrictions when following assigned routes. Recent reports of increased fighting between members of rival factions have been noted in areas west of Chesapeake Bay. U.S. aircraft have reported being engaged by small arms ammunition. At this time there is no reported confirmed enemy activity west of Chesapeake Bay.

b. Coordinating Instructions:

(1) All tactical and fixed navigation aids are not known to be operational to include USAF Air Traffic Control (ATC) services. Attempt to contact ATC on published frequencies.

(2) U.S. Air Defense Forces have defined safe passage air corridors. When brigade sectors and phase lines, contact must be established with the controlling unit prior to crossing. Since Divisional ADA will be deployed at critical phase lines and US fighter cover will be flying CAP, IFF Codes will be used.

a.) ROUTE OF FLIGHT/CHECK POINTS

- AA Weide to Norrisville Substation (ADMIN Altitude((Call Substation)
- NORRISVILLE SUBSTATION to FOWLESBURG (Call FOWLESBURG) 1000'
- FOWLESBURG to CP SANITARIUM (Call SANITARIUM)
- Depart SANITARIUM via route and proceed to LOC RAVEN DAM (Call LOCH RAVEN) (Altitude 1500')
- Depart LOCH RAVEN for RP LAESIDE (ADMIN Altitude)

(3) Weather: Sunrise 0630, Sunset 2020
Moonrise 2130, Moonset 0445
Percent Illumination 25
Temperature +42
Pressure altitude max +400
Winds 240/10
Low ceilings (800') and decreasing visibility (1 mile) throughout the day.

SERVICE SUPPORT: Maintenance AA WEIDE, Fuel available at WEIDE and Easton (Call for svcs. If required).

COMMAND SIGNAL: Call required checkpoints on 126.2 (VHF)

'Scenario #1' Description

'Scenario #1' presented a somewhat routine passenger transport flight in which pilots would be required traverse areas familiar, proceeding in timed sequences through checkpoints while maintaining ratio communication with ground personnel. Given that all participants had previous experience flying this particular terrain, assessments of risk made were expected to be minimal. However, as the intent of the mission was air travel of a military nature, a modicum of risk is associated thus it should be expected that all safety precautions be addressed and proper passenger guardianship procedures adhered to. In this scenario, irregularities were placed in hopes that these would call pilot attention to the fact that no flight should be considered routine.

Irregularities introduced were: 1) pilots were required to return from flight with the Division commander as a passenger on-board; 2) a potential for hostile elements in or around the area of flight existed, to include the use of small arms (this flight necessitated altitude restrictions, thus flying low possibly over ground forces capable of reaching the aircraft with ordinance is a potential concern); 3) all tactical and fixed navigation aids were not know to be operational; 4) contact was required with friendly ground units prior to proceeding through protected flight corridors; 5) fighter cover was required, thus it should be realized that a

threat must exist at some location in or adjacent to the planned flight path, and; 6) illumination was expected to be only 25 percent, with decreasing visibility.

Scenario #2

ARTEP 1-100-30-MTP/ARTEP 44-117-21-MTP
TASK: AIR DEFENSE for FARP RELOCATION followed by DEFENSE of CONVOY

EXPECTED TIME OF DEPARTURE: 0300

1. SITUATION:

a. Peoples army of Sconzia has stepped up operational tempo in your area. Since the Sconzia's last forward advance, enemy artillery has become a greater threat to the aviation assets of the 123d ATK BN. Enemy strength continues to increase with the insurgence of newly conscripted personnel. Friendly resistance patrols have discovered newly constructed enemy positions which appear to be designed for the employment of ADA or SAM's. If construction of the sites is allowed to continue to completion and operational status is obtained, friendly aviation operations will be in serious jeopardy.

b. The likely avenue of approach of enemy aircraft is from the north. Intelligence indicates there are enemy snipers in the area of operations. OPFOR aircraft have been observed in the immediate area of operation.

c. It is known that the enemy possesses indirect artillery with capability to range present FARP site, with possible ADA/SAM capabilities. OPFOR aircraft have been observed in the immediate area of operation. Intelligence has informed units of snipers in the area.

2. MISSIONS:

a. The POL Platoon, HQ CO, 123d ATK BN, will conduct FARP aerial relocation operations in support of a night, AH-64 deep attack mission using K Troop 2/7 CAV aircraft. The FARP will relocate using two of A CO, 123d ATK BN's UH-60's from (NK

560029) and have FARP operational NLT 040230 NovXX at (NK 628031). You duty is to provide air support for this operation

b. Your subsequent duty is to provide of air defense from the immediate area of the relocated FARP for 2nd Brigade's tactical road march from Irwin City to the tactical assembly area, vicinity NK356215, NLT 010300MarXX.

3. CONDITIONS:

a. Two UH-60's on site will move your refueling equipment and set-up personnel to the jump FARP (forward) location, carrying four 500 gallon fuel Blivets to operate four refueling points at one time using two FARE systems. Your company is seriously over extended with other commitments to the battalion. You have a limited number of personnel and aircraft to conduct this mission, 50% of those personnel have recently transferred in from northern climates, have had minimal training with your unit, and have never conducted an operation of this nature. However, your copilot has.

b. Following your FARP relocation mission, your second assignment will be to offer air defense for a road march to the Avenger Platoon Leader of A Battery 4th BN 44th ADA, whom you have been previously deployed at the National Training Center during the past two weeks. It is currently 201300FebXX, and your mission to provide air defense for 2nd Brigade's tactical road march begins 010300MarXX. The first serial will SP at 0300 hrs, with the subsequent serial departing at 0315 (Estimated time of travel is uncertain due to driving under night vision devices and driver proficiency and experience.). The convoy speed limit is 25 MPH with a catch up speed of 30 MPH. All vehicles will be on line two hours prior to roll out and will have TC's Night vision devices for use during this move. Your company is at 85% personnel strength, 50% of which are new to the unit and have never deployed to a desert environment.

Map recons indicate that the convoy will be traveling on unimproved roads with some steep slopes of more than 22 degrees. Soil conditions are firm and rocky with large subsurface rock formations.

c. Temperatures for March at NTC range from high's in the 50's to low's in the 20's (F) with strong winds. Precipitation during March averages approximately 2". There is a forecast for windy conditions. The weather has been dry and hot, with no forecasted precipitation. The temperature is averaging 93 degrees Fahrenheit during the day and 68 degrees Fahrenheit at night. The moon will provide only 5% illumination throughout the operation.

d. You have been at NTC for the past two weeks, conducting tactical operations for the past three days. It is 032100NOVXX. You have just received orders to assist with air defense in relocating the FARP, to have it operational at the new location (NK 598031) no later than 040230NOVXX.

4. Subsequent FACTS:

a. During your time at NTC you have planned and participated in two field training exercises (FTX) in preparation for this rotation. The company safety officer has conducted a force protection (safety) assessment of all personnel within the company. Based on that assessment you know 10% of the pilots in your platoon have been identified in a high or extremely high risk category for accidents (below standards, possibly due to lack of self discipline). You noted during the last FTX, pilots in your Company sometimes only had 8 hours of rest in a 24 hour period and appeared extremely fatigued.

b. Though you have supported FARP operations and POL support missions over the past year, you have been involved in only two night operations using NVDs during that time. However, night vision refresher training was conducted last month. There is, however, a lack of training time available due to enemy threat.

c. The new FARP location has been reported to have sparse vegetation, and scrub brush. Soil conditions are conducive for dust/brownout conditions. The S-3 has completed an aerial recon of the location, but no one from your company, including yourself, is familiar with this site. TACSOP states there must be good visibility to identify aircraft, but does not address procedures for limited visibility.

'Scenario #2' Description

Scenario #2 presented greater danger than scenario #1 especially due to fatigue, concerns for pilot inexperience, and for enemy action. In this scenario two typical missions were combined to illicit risk assessments decreeing fatigue (due to mission duration) and personal threat (as a result of known prior active enemy within the area). The first part of this mission required pilots to assist in the deployment of a forward area refueling point (FARP) to allow servicing of friendly aircraft forward of a line of safety. The second part of this mission called for pilots to escort an incoming convoy (who would be performing a tactical road march) by providing air support throughout hostile territory.

The areas being flown had experienced enemy action to include artillery (air defense artillery and surface-to-air missiles), and enemy strength was expected great with troops having been refreshed recently. Mission departure time was 0300 hours and the duration of the mission should require that pilots continue flying into the night. The potential FARP area is located in dusty terrain increasing the possibility of 'brown-out' (rotary aircraft flying close to the ground disperse loose dirt, causing poor visibility). Other friendly aircraft (two UH-1 helicopters), necessarily flying in close formation with the Cobras, will be transporting flammable

material. With this, personnel in the Cobra Company will have already performed overextended duty, replacement aircraft are scarce, personnel limited, and 20 percent of these pilots are new to the unit and have never conducted an operation of this nature.

In this scenario the convoy will have departed prior to flight thus personnel will most likely be tired by the time of rendezvous so stragglers are expected. The terrain over which the convoy must travel consists mainly of unimproved roadway, thus travel time is expected slow causing longer aircraft exposure to the enemy. Additionally, expected weather conditions were extreme wind with high temperatures and thin air, moon illumination of only 5 percent is anticipated (which may be good for the convoy though not so for pilots flying at night). Per a pre-flight safety assessment it was discovered that 10 percent of the Cobra pilots have been identified as in a high or extremely high risk category for accidents (which is below standard). Finally, the pilots average rest within the previous 24 hours is estimated at only eight hours, experience with night vision devices (NVD) limited, and none are not familiar with the FARP site in question.

Scenario #2 (RELOCATE THE FARP) Acronym Definitions

ARTEP {Army Training Evaluation Program}

POL {petroleum/oils/and lubricants}

HQ CO {headquarters company}

ATK BN {attack battalion}

FARP {forward area refueling point}

AH-64 {attack helicopter}

CAV {cavalry}

CO {company}

UH-60's {utility helicopter}

(NK 560029) {'NK' is a reference to a particular map coordinate XXXXXX}

NLT {no later than}

SAM's {surface-to-air missiles}

NTC {National Training Center}

fuel Blivets {round rubber bladder transportable fuel storage tanks/devices}

FTX's {field training exercises}

NTC {National Training Center}

NVDs {night vision devices} during that time.

recon {reconnaissance}

METT-T {part of a minimum essential task list} ANALYSIS

TACSOP {Tactical Operations Center Standard Operating Procedure}

OPFOR {opposition force}

Scenario #3

OPORD 07-91 REFERENCES: Map Sheet 2317 II

EXPECTED TIME OF DEPARTURE: 0400
TIME ZONE USED THROUGHOUT ORDER: Local
TASK ORGANIZATION: TF A/7-101 - A/7/101 - TM/PFDR

1. SITUATION
   a. Enemy Situation
      (1) Terrain: The area of operations is vegetated/desert with

      rolling hills. Valleys run generally north-south.

      (2) Weather: Sunrise 0600, Sunset 2000
      Moonrise 2130, Moonset 0445
      Percent Illumination 30
      Temperature +24
      Pressure altitude max +500
      Winds 240/10
      Low ceilings (1000') and decreasing visibility (1.5 miles) throughout the day.
      (3) Forces: Inf/Ar Bde vic VK 9483 augmented with ADA, FA, and air support.

   b. Friendly Situation:
      (1) 3rd Inf Bde vic WK 15 65 will conduct a daylight attack to secure the high ground at Objectives Alpha, Vic CK 98 80 and Bravo, vic 87 77.
      (2) Your unit has been actively operational during the past three days, last mission flown by yourself and crew was of four hour duration which took place yesterday ending 1830 hrs.

2. MISSION: Conduct air assault from PZ CALVIN (WK064-554) with TF 2-505 to destroy Class V storage site vic VK 87 78 (Objective Charlie) and return to PZ HOBBES (VK 904 544). On order, pick up ammunition (M102 A22 Bag) at PZ HOBBES, deliver to C 1/76 FA at LZ JON (WK

006 676), and return to CALVIN. Be prepared to conduct additional re-supply missions from CALVIN.

3. EXECUTION:

a. Concept of the operation: This is a priority mission. The first mission is a five aircraft air assault to destroy an ammunition storage site in conjunction with 3rd Brigade's main attack. TF 2-505 must be in place prior to the main attack. Timing is crucial for this operation. Except for the required radio call at RP1, the air assault mission will be conducted under radio silence. The second mission is air defense in support of a re-supply mission for an artillery battery so they may continue to support the attack. Flight corridors will be used for both missions.

b. Techniques of Movement:

   (1) Air Assault: From CALVIN to SP1 (LUCY), WK 065 585; Via Corridor 1 to ACP1, WK 035 687; ACP2, WK 029 745; ACP3, WK 010 790; RP1 (LINUS), VK 920 790.

   (2) Re-supply: From HOBBES east northeast via corridor 3 to the high ground in grid square 02 59, then north to the Jagst river, then northwest along the river to JON.

c. Fires: C 1/76/M102, Priority of fires (1) 2-505 (2) 3rd Bde

d. Terrain: CALVIN to LUCY is a distance of 3 kilometers (km) of thick vegetation consisting of tall tree coverage; LUCY to LINUS via Corridor 1 (APC1, APC2, APC3) encompasses a distance of 11 km to ACP1 partially tree lined with rocky hills followed by valley areas possessing tall thick vegetation, then 5 km to ACP2 of completely open terrain with no vegetation nor hills or ravines, then 9 km to ACP3 of hills and valleys possessing sparse tree cover with 2 communication sites maintaining tall antennas, for a total Corridor 1 distance of 25 km; LINUS to HOBBES is a distance of 6 km open ground with sparse vegetation through not mountainous; HOBBES to High Ground via Corridor 3 is a distance of 5 km of open sparse vegetation with some small elevations and few shallow ravines; High Ground to Jagst River is a distance of 8 km becoming mountainous with vegetation and deepened ravines; Jagst River to JON is a

distance of 5 km of dense vegetation with tall tree cover and especially deep ravines along the river bed.

e. Coordinating Instructions:
   (1) Assembly area is SUSIE
   (2) Penetrate FLOT vic ACP2
   (3) Friendly ADA status/IFF is Tight/Off 1 km prior to FLOT
   (4) Actions on enemy contact will be reported immediately.

4. SERVICE SUPPORT:

a. Class III, FARP locations at CALVIN, HOBBES

b. Class V, AA SUSIE and FARP locations at CALVIN, HOBBES.

5. COMMAND AND SIGNAL

a. Command
   (1) AATF Cdr location – CALVIN

b. Signal
   (1) CEOI in effect
   (2) Call signs:
   TF 7/101 Avn TOC – P41
   2-505 AATF TOC – Y35
   C1-76 FA – S21
   Team Pathfinder (CALVIN) – C4

Team Pathfinder (HOBBES) – H44

'Scenario #3' Description

Scenario #3 was similar to scenario #2, however posed a greater threat to bodily harm. Of greatest concern in this scenario was the essential timing called for (pilots were required to position aircraft at given map coordinates during specific periods, thus could not fly fast or jump ahead through open terrain and expect to 'wait' in areas providing cover and considered relatively safe). Equal concern was for mandated flight through assigned corridors, some of which easily exposed pilots to ground fire (completely open terrain with little vegetation, and few hills with thin or no ravines with which to hide behind). Others assigned corridors contained hazards such as tall antennas and enemy surface-to-air missile installations.

Low ceilings with decreasing visibility were presented, and enemy engagement was anticipated this being an attack mission. Also of concern were the facts that air support was deemed necessary (curing pilots to the possibility of air-to-air combat), and enemy missile defenses had been reported, and as the unit had been active for the past three days fatigue is an issue. With this, hazards posed by refueling and rearmament in a forward position will exist, though it is expected that these be conducted even under hostile conditions. Additionally, radio silence is in effect, allowing little or no contact with friendly forces for further information

on status of mission or position of hostile forces. Finally, the first attack (of two missions) is considered essential thus must be completed at all costs, and along with this severe condition the terrain itself is relatively unknown.